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Stratigraphy and Sedimentology of Holocene Overbank Deposits of the Mississippi River, False River Region, Louisiana.

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STRATIGRAPHY AND SEDIMENTOLOGY OF HOLOCENE OVERBANK DEPOSITS OF THE MISSISSIPPI RIVER, FALSE RIVER REGION, LOUISIANA

A Dissertation

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by
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ABSTRACT

The Holocene flood basin along a meander belt margin of the Mississippi River includes two principal geomorphic features: a flat featureless natural levee, and a system of anastomozed, entrenched crevasses with intervening splay lobes. Levee and splay lobe deposits are identical and consist of thinly (cm) to minutely (mm) rhythmically layered sand, silt and clay which are pervasively disrupted by unlined meniscate burrows of the trace fossil, *Muensteria*. Pelletal fabrics develop where overlapping backfilled burrows completely obliterate primary stratification so that only traces of small ripple laminations and parallel laminations are preserved. Pelletal silt is the most extensive lithology present.

A proximality trend in stratification is present relative to distance from sheet flood sources. With increasing distance from the trunk channel and crevasses, sandy rhythmites are successively replaced by finer-grained and more thinly interlayered deposits such as silty rhythmites and interlaminated silt and clay. As layering thins distally, burrowers more effectively disrupt the sediment and stratification grades into pelletal silt, pelletal mud and pelletal clay of the backswamp. Thus levee and splay lobe deposits are identical except that the same lithofacies extend further basinward on splay lobes.

The crevasse fill includes mudball conglomerate, plant debris, complex clay-rich laminates, graded sands, mottled muddy sand and minor ripple laminated sand.

The sedimentology reveals that both morphologic features formed in

an analogous manner, by sheet flow sedimentation. This result differs from previous views that 1) levees form from overbank flooding and sheet flow and 2) crevasse splays form via the crevassing process which generates thick, sharp-based, fining-upward cross-stratified sands. The crevasse channels and splay lobes are not depositional features that formed as minor mouth bars, crevasse channels, lenticular channel sands, and barforms migrated basinward. Rather, after crevasse entrenchment, the splay lobes accreted by overbank flooding and sheet flood sedimentation.

After establishment of the meander belt (marked by a lithologic change from lake clays to subaerial pelletal silt) two episodes of levee/splay progradation (3-4 m thick) are recorded. Each represents the gradual migration of the trunk channel towards the site, and abruptly ends with a neck cut-off.

CHAPTER 1. INTRODUCTION

The Holocene flood plain deposits of the lower Mississippi Valley are divisible into two major fluvial facies, meander belt sands and a finer grained flood basin facies (Fisk, 1947). Meander belts, defined as the zone in which the river meanders, are principally composed of point bar deposits. Flood basins, the low-lying regions in a flood plain adjacent to or between meander belts, are principally overbank in origin.

By definition, overbank deposits are those sediments deposited outside the confines of the river channel from standing or flowing water (Wolman and Leopold, 1957). The most important overbank environments from an economic standpoint are natural levees and crevasse splays which form relatively coarse-grained permeable wedges of sediment that extend and thin basinward from the margin of meander belts, merging distally into finer-grained, impermeable backswamp deposits. These permeable facies have the potential of connecting meander belts which serve as major petroleum reservoirs. Overbank deposits are often a neglected facies in the Mississippi Valley, and in other modern and ancient fluvial systems even though they are often volumetrically more important than meander belt sands (Jackson, 1978; Allen, 1978). The basic sedimentology, the vertical sequence record, and depositional processes of overbank deposits have been neglected because previous workers have been preoccupied with the stratigraphic sequence and sedimentology of point bar deposits.

Each unique morphologic feature in a modern depositional environment such as a levee or crevasse splay is produced by a combination of processes that act together to form a deposit with specific lithologic characteristics and form (Potter, 1967). From a process standpoint, it is commonly assumed that levees and crevasse splays form by distinctly different sedimentologic processes because each sub-environment has a unique morphologic expression. Levees are flat featureless plains that slope toward the flood basin. Crevasse splays consist of an anastomozing network of crevasse channels with intervening lobe-like features. Sedimentation processes in overbank environments and general characteristics of the resultant deposits have been discussed by Bridge (1984), Fielding (1984), Smith (1983), Hughes and Lewin (1982), Reineck and Singh (1980), Elliott (1974), and Allen (1965).

Sedimentologic models for fluvial levee and crevasse splay formation (i.e. Elliott, 1974) are based for the most part on observations of modern crevasse splays in interdistributary bays of the lower delta plain, ancient interdistributary bay sequences, and ancient crevasse splay sandstones, which may or may not represent analogous features. The assumption that separate unique processes act to form a deposit of a given shape has not been substantiated by observations of stratification in modern fluvial deposits. Thus the major thrust of this research is to determine how geomorphic form and internal stratification for both levee and crevasse splay deposits in a single large meandering system, the Mississippi River are related. The key to understanding the processes of levee and crevasse splay formation lies in the sedimentology and stratigraphy of the deposits.

From a descriptive standpoint, the sedimentology and stratigraphy of modern levee and crevasse splay deposits are virtually unknown. In the fluvial sector of the lower Mississippi Valley both the three-dimensional distribution of meander belts and flood basin deposits (Fisk, 1944, 1947, Saucier, 1969) and the morphology of sub-environments (i.e. Saucier, 1969) have been mapped. Even though the sedimentology of other sub-environments such as upper point bar scroll bars (Ray, 1976; Davies, 1966), upper point bar crevasse splays (Kappa et al, 1987), lower point bar (Frazier and Osanik, 1967, Hayes, 1985), backswamp (Coleman, 1966; Krinitzky and Smith, 1969), and lakes (Coleman, 1966; Krinitzky and Smith, 1969; Tye, 1986) has been re-examined in detail since Fisk's monumental work (Fisk, 1944; Fisk, 1947) very little is known about the stratification and sedimentology of flood basin levees and crevasse splays.

Outside the Mississippi Valley a similar situation exists. Most studies of the stratification of modern fluvial environments have been restricted to channel or meander belt deposits (i.e. Harms et al, 1963; McCowen and Garner, 1970; Levey, 1976; Jackson, 1976A and 1976B, Kappa et al, 1987). The most notable exceptions are the studies of levee and crevasse splay deposits along a meandering stream by Singh (1972) and a braided stream, the Brahmaputra River by Coleman (1969). Both of these studies were based on sedimentologic descriptions from shallow trenches, low scarps and cutbanks (less than 3 m of section) preserved near or within channel margins. Smith (1983) and Cross and Smith (1985) used a three-dimensional approach utilizing cores to understand the distribution of both overbank and channel facies of an anastomozing river system. This study is the first to systematically sample levees and crevasse splays in a meandering system with cores up to 10 M long in unexposed flood basin areas away from the meander belt.

Even though flood basin sequences in fluvial depositional systems provide a much more complete record of sedimentation than that found within meander belt sandstones, they have not been documented until now. In contrast to the point bar sequence which records the history of a limited segment of meander belt, vertical sequences through fluvial levee and crevasse splay deposits can provide an independent record of channel pattern development and events in flood basin evolution. These events include the avulsion history of the basin, crevassing events, progradation and abandonment phases in levee and splay development and individual floods (Elliott, 1974; Bridge, 1984). The flood basin sequence is a stack of cycles within cycles which represents a hierarchy of events in basin evolution. This contrasts with the channel sandstone sequence whose multiple channel-floor diastems have removed great thicknesses of strata. Meander belt sandstones record discontinuous events with respect to basin evolution such as the last phase in the meandering history of the channel or an avulsion as indicated by the lithology change from sandstone into the overlying mudstone member.

Flood basin sequences may provide additional, previously ignored information on the channel pattern in an ancient alluvial sequence. Channel patterns have traditionally been determined by focusing on the geometry and sedimentary structures in channel belt sandstones and ignoring the flood basin member of the sequence. The problems in determining the channel behavior from outcrops of fluvial channel belt sandstones have been enumerated by Friend (1983) and Bridge (1985). Since a continuum in bar forms exists between braided and meandering systems (Bridge, 1985), similar stratification sequences could occur in channel belts of both types of deposits. As a consequence, it may not be possible in many cases to distinguish stream pattern from channel belt deposits alone (Bridge, 1985).

Channel patterns were also at one time ascertained by the proportion of fine-grained deposits present in an alluvial sequence. For example, a large proportion of fine-grained deposits was thought to indicate a meandering channel pattern (Collinson, 1978, p. 578). However, the overall proportion of fine-grained (overbank) sediment in a sequence is not an index of channel pattern (Friend, 1983, p. 348). Overbank deposits may be volumetrically unimportant or missing in a fluvial sequence for a variety of reasons. Their presence or absence is controlled by the degree of interconnectedness between channel belt deposits which is a function of 1) avulsion frequency, 2) aggradation rates, 3) channel-belt width/flood plain width, 4) rates of tectonic subsidence (Bridge and Leeder, 1979, Bridge, 1985), and sea level rise rates. Even if the overbank facies is preserved only as sporadic remnants in an alluvial sequence, these remnants can be used to illucidate the history of the basin and perhaps the channel pattern itself.

It is the purpose of this research to focus on the sedimentology, stratigraphy, processes and geometry of Holocene levee, crevasse splay and backswamp deposits in the Lower Mississippi Valley. Specific objectives are:

1) to describe the basic sedimentology of levee and crevasse splay deposits and to determine whether the two sub-environments are differentiable based on sedimentologic criteria,

2) to show how stratification in flood basin deposits changes with respect to distance from the source of sheet floods,

3) to present models of crevasse splay and levee formation based on the sedimentology observed,

4) to compare and contrast the Mississippi Valley levee and crevasse splay deposits with previously described modern and ancient levee and crevasse splay deposits,

5) to determine what cyclic processes such as meander belt establishment, progradation and abandonment of levees and splays and flood events are preserved in vertical sequences through these deposits, and

6) to present a depositional model for flood basin accretion in response to meander belt establishment.

The study area is located in the lower Mississippi River Valley (Fig. 1) about 35 km northwest of Baton Rouge, Louisiana. It is centered about False River, an oxbow lake which lies at the margin of the presently occupied channel belt (Fig. 2). Upper point bar deposits were examined at Solitude and Thomas Points which are both active point bars along the Mississippi River (Fig. 2).

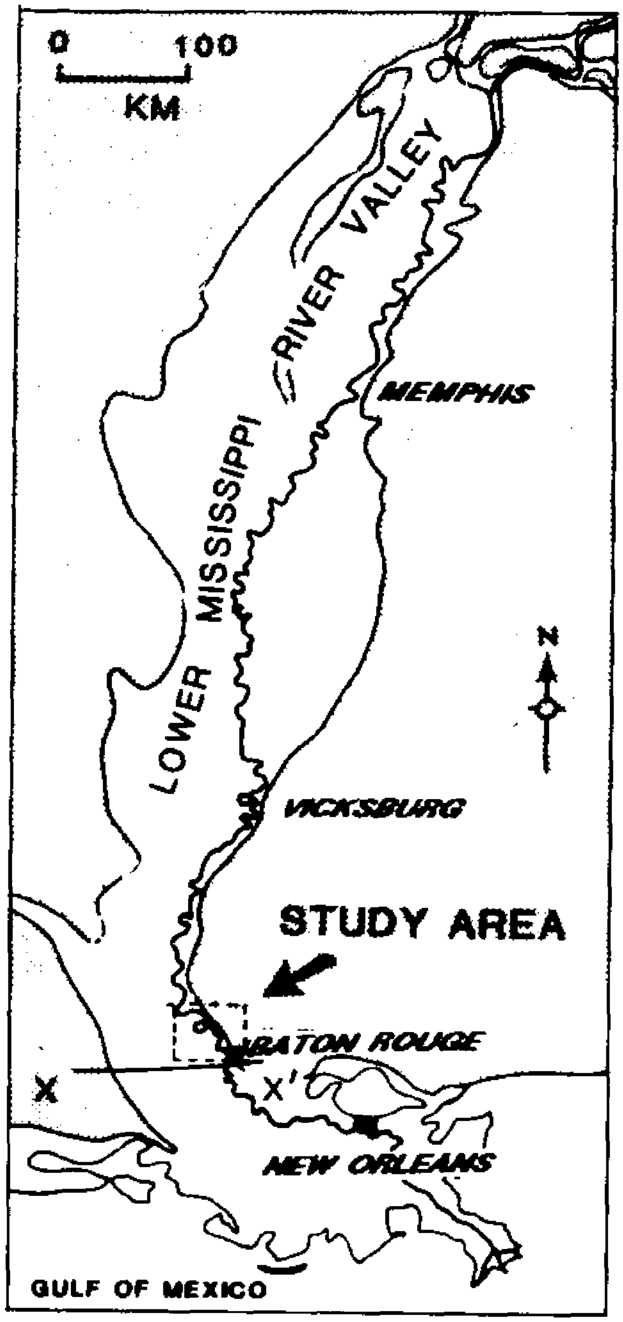


Fig. 1- Location of the False River Region, Solitude Point and Thomas Point with respect to the Lower Mississippi Valley. Profile X-X' is shown in Fig. 3.

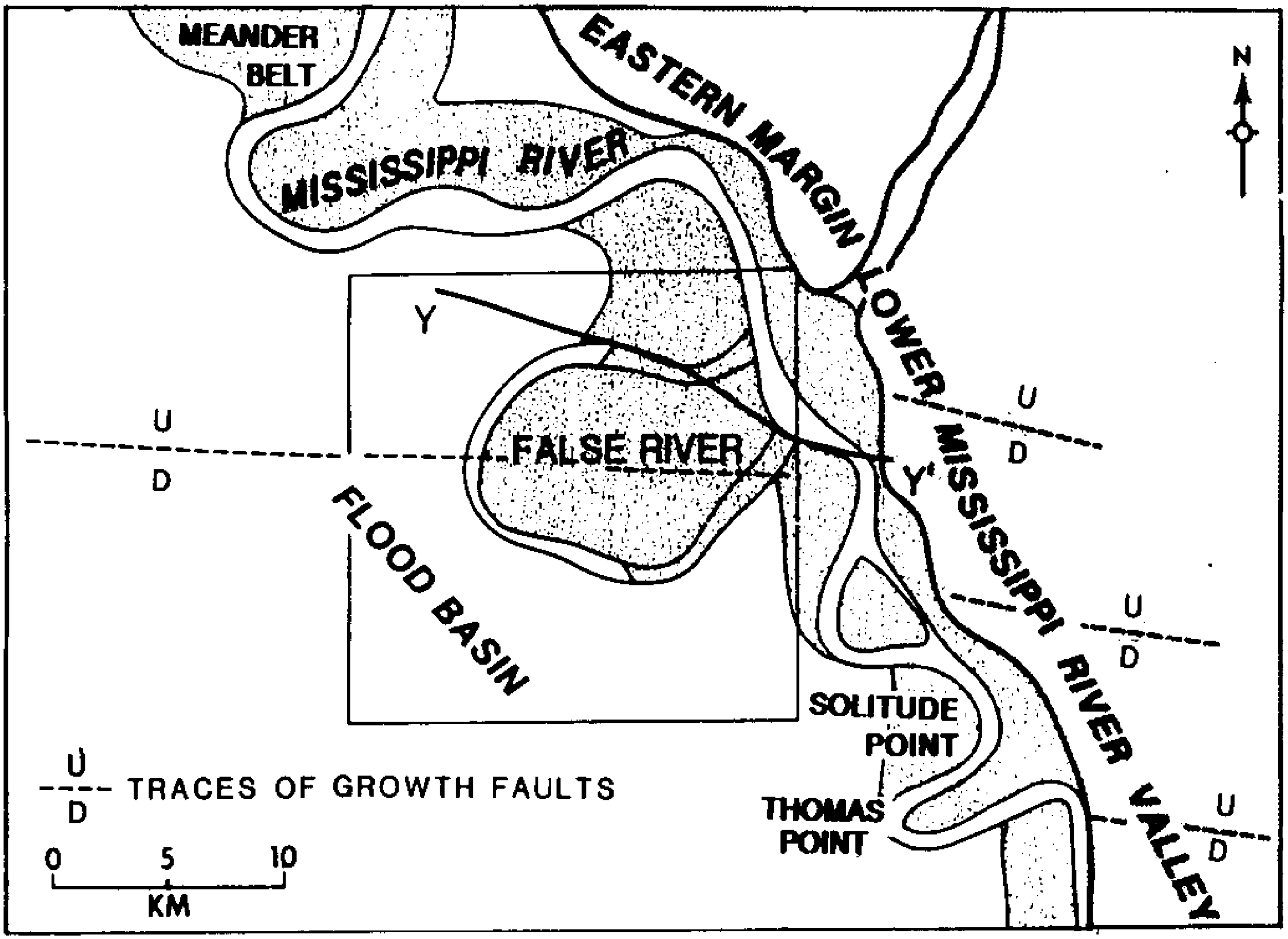


Fig. 2- Location of the False River region with respect to the presently occupied meander belt of the Mississippi River. Fault traces are from Saucier, 1969.

CHAPTER 2. QUATERNARY GEOLOGY OF THE LOWER MISSISSIPPI VALLEY

GEOLOGIC HISTORY

The lower Mississippi Valley is part of the Gulf of Mexico Coastal Plain Province. Fisk (1944) divided the valley fill into two units (Fig. 3): 1) a lower 'substratum' deposit, mainly consisting of late Pleistocene(?) sand and gravel and 2) an upper 'topstratum', consisting of Holocene meander belt sands and intervening flood basin silts and clays.

The contact between the 'substratum' and 'topstratum' appears to be very sharp (I.B. Singh, personal communication) and it has been mapped throughout the valley with cores and borings through the flood plain (Fisk, 1944). This contact supposedly represents the transition from braided stream deposits of late Wisconsinan age to the meandering stream deposits of the Holocene. Very little is actually known about the spatial arrangement of lithosomes in the 'substratum' and the details of the stratigraphic transition from the 'substratum' to the 'topstratum' (Jackson, 1978; Singh, personal communication).

Saucier (1974) infers from radiocarbon dates that near Baton Rouge the transition from braided to meandering stream deposits took place about 12,000 years ago. McFarlan (1961) however dates the base of the 'topstratum' near Baton Rouge at 9950 ± 200 years.

According to Fisk (1944) the following sequence of events took place during the late Pleistocene evolution of the lower Mississippi Valley. During late Wisconsinan time, sea level dropped to about 122 m (400 ft) below the present mean sea level. This was a time of

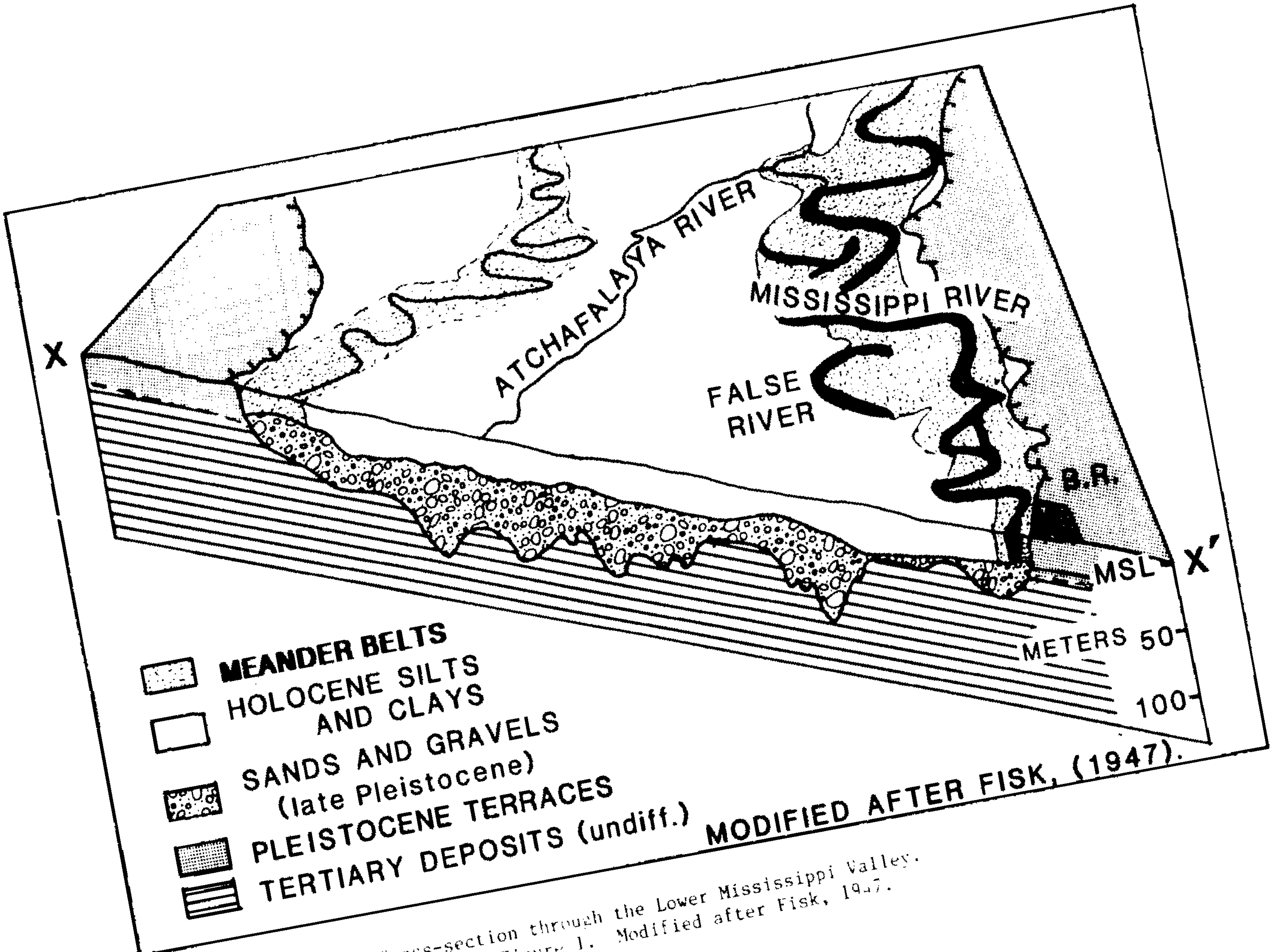


Fig. 3- Cross-section through the Lower Mississippi Valley. X-X' is shown in Figure 1. Modified after Fisk, 1947.

lowered base level and the valley was entrenched. When sea level began to rise during the Holocene transgression, base level also rose. The valley began to fill with braided stream deposits. At some critical change in slope, meandering deposits suddenly replaced the braided stream deposits. A delta plain built out into the Gulf of Mexico seaward from the vicinity of Baton Rouge. Periodic avulsions caused a shift in the position of meander belts and distributaries and fine-grained deposits accummulated in intervening flood basins.

A cross-section through the flood plain near Baton Rouge shows the distribution of meander belts and flood basin deposits in this sector of the valley (Section X-X', Fig. 3). The segment of the modern channel belt which extends through the study area (Fig. 3) has been occupied for approximately 3000 years (Saucier, 1974). Earlier, the active channel belt was positioned along the western wall of the lower Mississippi Valley and a poorly developed drainage network existed in the vicinity of the present channel belt (Fisk, 1944).

Approximately 30 m of Holocene overbank clays and silts overlie an undifferentiated sand and gravel unit of late Pleistocene age (Fig. 3). The Holocene flood basin deposits in the Atchafalaya Basin are divisible into a stack of alternating poorly-drained swamp, well-drained swamp and lacustrine facies (Coleman, 1966; Krinitzsky and Smith, 1969).

Krinitzsky and Smith (1969) mapped 3 cycles of changes from lacustrine, to well-drained swamp deposits in the subsurface approximately 25 km southwest of the the study area (Fig. 4) in a core that was 48 m in length (Core PROJ 6RE). The uppermost cycle is about 14-17 m thick with the depth to the base of swamp deposits about 8-9 m

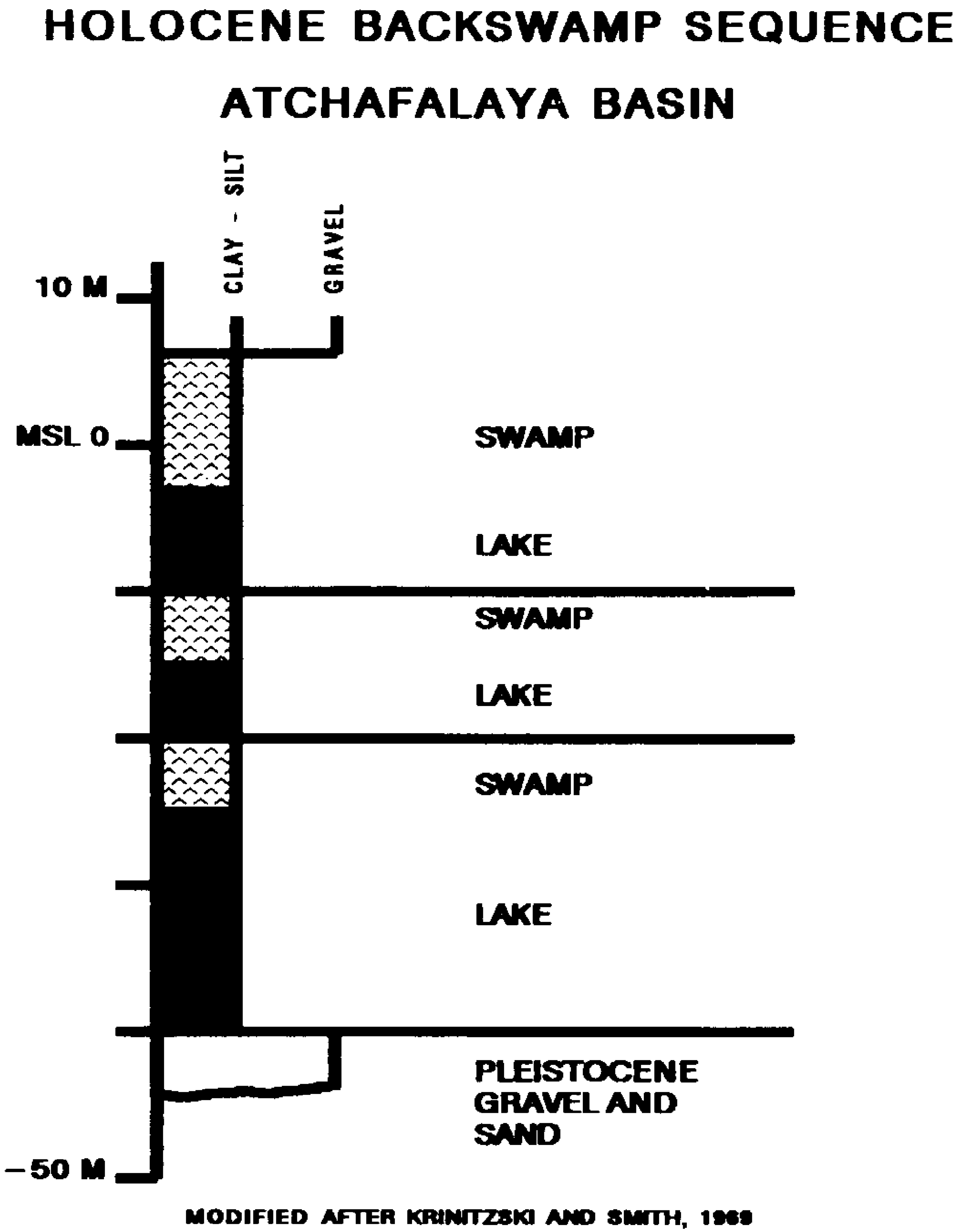


Fig. 4- Stratigraphic section through flood basin deposits in the Atchafalaya Basin. Data from Krinitzsky and Smith, 1969.

below the surface. Each of these shallowing-upward sequences in the flood basin is probably related to the establishment of a meander belt. The levee, splay and backswamp sub-environments under investigation in this report include the upper 10 meters of the youngest cycle.

Sharp facies contacts between meander belt sand and flood basin mud are ubiquitous along channel belt margins in the lower Mississippi Valley (Plate 5 in Fisk, 1947; Allen, 1965; Jackson, 1978). These contacts are principally the result of cutbank erosion along the margin of the channel belt due to the downstream translation of the meandering thalweg during point bar migration. In Figure 5, Saucier's (1969) cross-section through the channel belt margin in the study area has been modified to show the vertical extent of the contact between the flood basin and channel belt and the discrete positions of upper point bar, lower point bar and levee sub-environments.

GEOMORPHOLOGY

Distribution of Environments

The False River area (Fig. 6) has previously been morphologically divided by Fisk, (1944, 1947), Sternberg (1956), and Saucier (1969) and is the classic geomorphic locality for a meandering stream (Fisk, 1947, p. 14, Fig. 1; Allen, 1965, p. 122, Fig. 18; Collinson, 1986, p. 40, Fig. 3.48). Here excellent relict levee, crevasse splay and backswamp deposits are preserved in the flood basin adjacent to the channel belt (Fig. 6). Within the meander belt both concave bench and point bar deposits with their accretion topography are preserved. Oxbow lake deposits are also present. These deposits are part of the late Quaternary valley fill, deposited after the Wisconsinan low stand

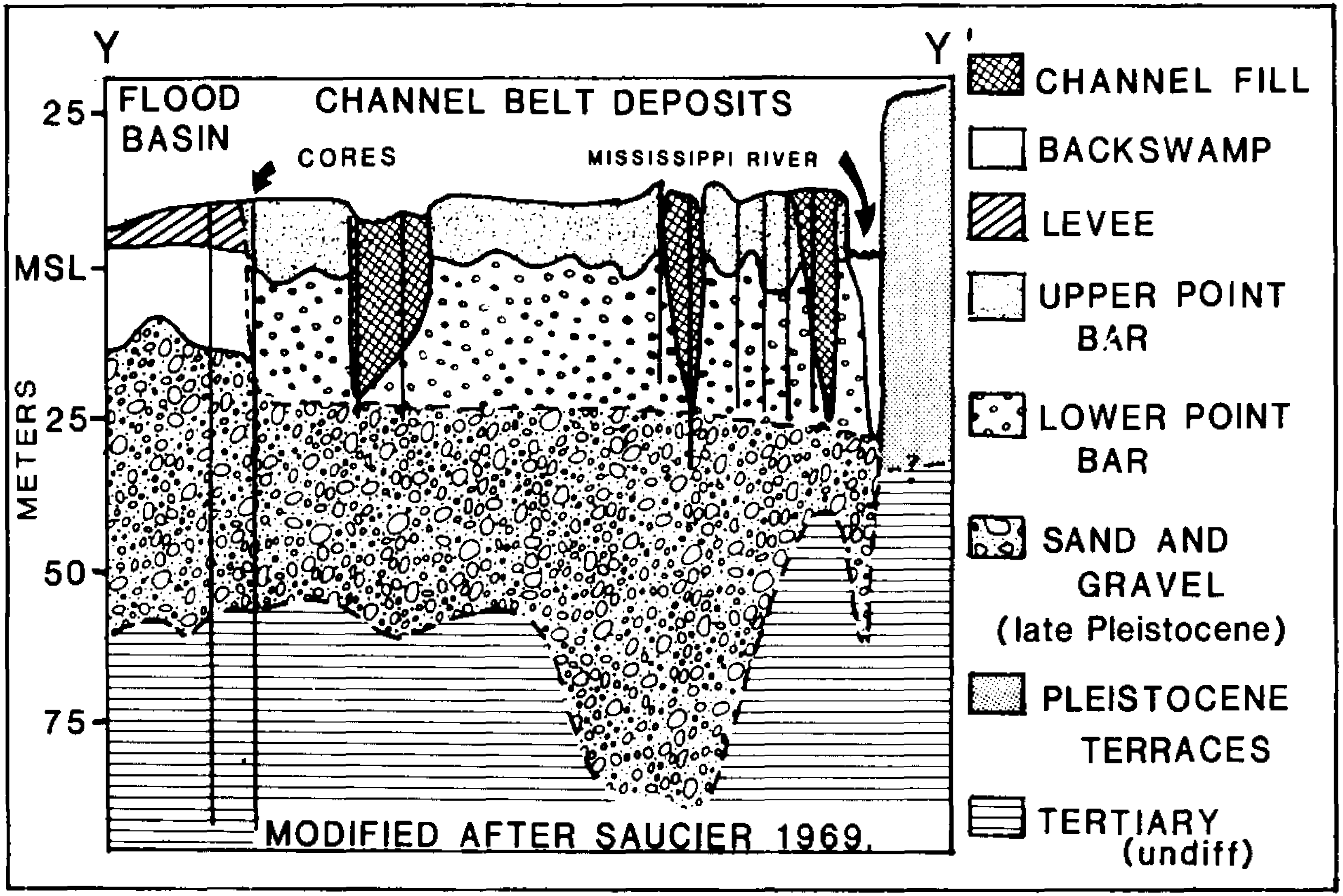


Fig. 5- Cross-section through the meander belt near False River Modified after Saucier, 1969. The position of Profile Y-Y' is shown in Figure 2.

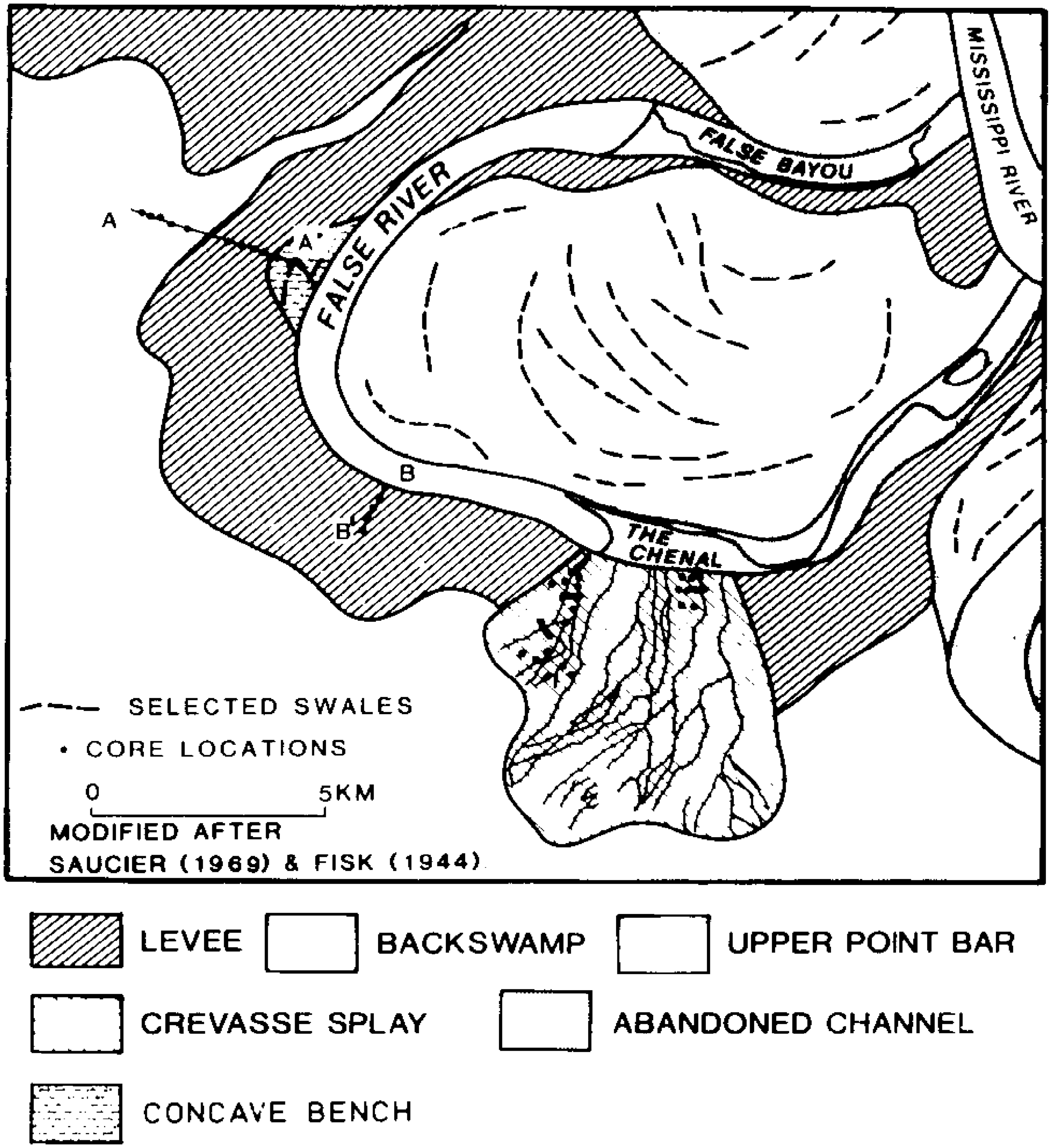


Fig. 6- Distribution of sub-environments in the False River Region. Modified after Saucier (1969) and Fisk, 1947.

of sea level during the Holocene transgression.

Levee and Backswamp-- The natural levee is a flat, nearly featureless plain that is about 3 km wide (Fig. 6). It has a maximum elevation of about 11.6 m above mean sea level (M.S.L.) at the edge of the oxbow lake. The lowest part of the flood basin to the west has an elevation of 2.5 m above M.S.L. The levee dips very gently from the meander belt margin towards the backswamp at a slope of about 1.5-2.0 m/km. Distally it merges with the backswamp which also dips towards the center of the flood basin but at a lower angle. It is restricted to the concave side of the meander bend (Fig. 6). The levee is locally dissected by a number of crevasses along the southern loop of False River.

The levee bordering False River is a segment of the highest natural levee system that occurs anywhere along the Mississippi River (Fisk, 1947, p. 43). This levee is 9.1 m in height relative to a meander belt that is about 30 m thick. The maximum height of the levee is calculated as the difference in elevation between the highest point on the levee (11.6 m above M.S.L.) and the lowest point (2.5 m above M.S.L) in the adjacent backswamp to the west. This difference in elevation is caused by aggradation of overbank sediment mainly by vertical accretion into the flood basin during the establishment and evolution of the meander belt. The height of the levee may have been enhanced here by faulting which could affect sedimentation on the downthrown block of an east-west trending fault zone (Fig. 2).

An average sedimentation rate of 0.3 cm/yr is calculated as the rate of flood basin accretion at the levee crest. This rate was calculated from the maximum thickness of the wedge of overbank material (9.1 m) and the age of the meander belt (3000 years). Kesel et al (1974) calculated a similar sedimentation rate of 0.275 cm/yr for flood basin aggradation based on the average thickness of 'backswamp' accretion (1.1 cm) measured during a major flood in 1973 and the 4 year recurrence interval of that flood.

Along the Mississippi River, the natural levee is best developed along the concave side of meander loops (Fisk, 1947). Sedimentation on natural levees results from levee overtopping events. Sheet floods cascade over the top of the natural levee and then decelerate into backwater regions.

Crevasse Splays-- The crevasse topography (Fisk, 1947) consists of an anastomozing network of crevasses and accompanying splay lobes which cover an area of approximately 25 square km. These crevasse splays extend about 8 km out into the flood basin. The splays are about 1 to 1.5 m higher than the surrounding levee deposits. The lobes achieve their highest elevations along crevasses where they form low, narrow levees which are about 0.5 m higher than the splay lobes. These levees are highest in proximal parts of the splay and gradually merge with the splay lobes in flatter, distal parts of the splay.

Crevasse channels are deeply incised (to a maximum depth of 8 m) into the levee and backswamp deposits, are U-shaped in cross-section and for the most part are still unplugged. They apparently do not migrate since they are entrenched into the flood basin deposits. Distally the crevasses shallow, remain U-shaped in cross-section and flow into drainage networks which parallel the slope of the flood basin floor.

The levee around False River was initially crevassed at eight sites in a cluster along the downstream margin of the meander bend (Fig. 6). This is a common site for crevasses to form. The location of these crevasse sites may be a consequence of subsurface weaknesses due to down to the basin faults which trend east-west through the area (Fig. 2). Alternatively, crevassing could have occurred here as a result of main channel flow impinging against the concave bank in a tightly curved meander bend.

From eye-witness accounts Sternberg (1956) determined that the neck cut-off isolating False River from the main stream occurred at about 1700 A.D. To calculate the approximate year of crevassing, I assumed that crevassing and deposition of splay lobes for the most part occurred before the cut-off and divided the thickness of the splay lobe deposits (120 cm) by the average sedimentation rate (approximately 0.3 cm/year from Kesel et al 1974). This computation reveals that crevassing probably took place about 400 years before the neck cut-off during the year 1300 A.D.

Point Bar-- Point bar deposits probably make up the greatest volume of material preserved in meander belts. Although they are orders of magnitude larger in scale, Mississippi River point bars are similar in morphology to the Beatton River point bars (northeast British Columbia) described by Nanson (1980). Both rivers have point bars with two distinct morphologic levels.

Mississippi point bars consist of: 1) a vegetated upper point bar consisting of scroll bars and intervening swales (ridge and swale topography), and 2) an unvegetated lower point bar which forms as a convex-upward surface extending from the toe of the first scroll bar to the thalweg (Fig 7).

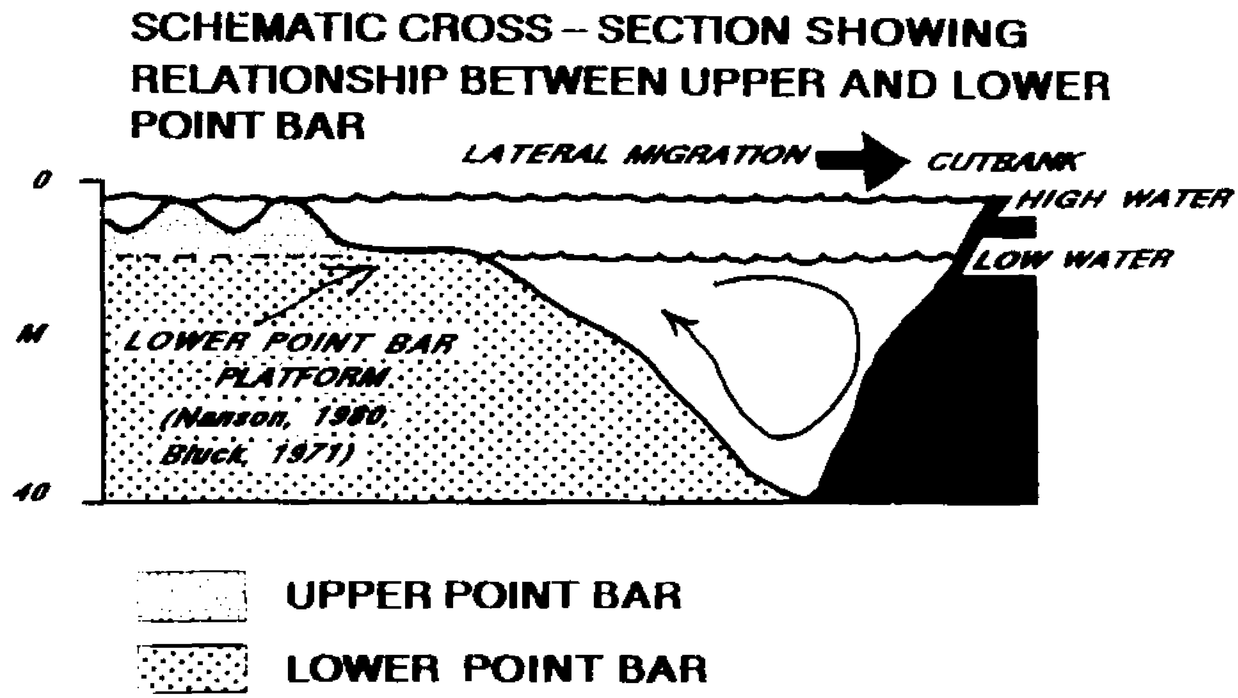


Fig. 7- Schematic cross-section through a Mississippi River point bar showing relationship between upper and lower point bar sub-environments.

The lower point bar of Mississippi River meander belts is analogous to Nanson's (1980) and Bluck's (1971) point bar platform. The point bar platform is the upper, nearly horizontal part of the lower point bar which is exposed at low water. The rest of the lower point bar is always submerged. A discussion of problems in point bar and scroll bar terminology is presented in Nanson (1980).

An excellent example of an active point bar on the Mississippi River is the point bar at Solitude Point (Fig. 2). Here, the unvegetated lower point bar has a maximum exposed width of about 150 m at low water (Hayes, 1985). The vegetated upper point bar with its scroll-bar topography has ridge crests that stand about 5-7 m higher than the lower point bar surface. The sub-parallel ridges are approximately 60-120 m in width and up to several kilometers in length. They are separated by intervening swales which have relatively flat bottoms and are wider than the ridges. The ridges stand about 4 m higher than the swale floors.

The upper and lower point bars are separated by a relatively steep, scarped slope with benches. The scarping occurs during falling water when waves erode the margin of the channelward scroll bar ridge. It is possible that this scarping is accentuated by man-made stabilization structures on the cutbank side which restrict point bar migration. The topographic surface that extends from the crest of the first ridge (or scroll bar), down the ridge margin, and across the lower point bar surface to the thalweg is the leading edge of point bar migration where laterally accreted beds are emplaced.

Upper point bar topography is caused by lateral accretion of the point bar, growth of longitudinal bars into ridges and their subsequent accretion onto the upper point bar, overbank flooding in swales and over the ridge tops, crevassing of ridges and infilling of swales during floods and possibly by lateral accretion of concave benches.

Concave Bench Deposits-- Concave benches are crescent-shaped benches which are situated along the upstream limb of the concave bank (Nanson and Page, 1983) of a meandering stream. In the study area, the concave bench occurs as an odd slice of meander belt preserved along the western margin of the oxbow lake (Fig. 6). It is crescent-shaped with a single swale and an island-shaped ridge (Fig. 8). The swale is parallel to the boundary between the meander belt and the flood basin.

There are three theories that explain the origin of concave benches. Nanson and Page (1983) have shown that concave benches develop downstream from the tails of point bars (Fig. 9A). The cutbank side of the stream erodes and retreats while the point bar side progrades towards the thalweg. Stream flow expands as it completes its passage around the point bar. A zone of reverse flow is set-up along bank just downstream from the point bar especially during floods.

Carey (1969) believed that concave benches form when abrupt angle turns in channels cause the mainstream flow to impinge like a jet against the cutbank side (Fig. 9B). As a result, the flow splits and a zone of reverse flow is set-up upstream from the impingement zone. An indentation is eroded into the bank which effectively isolates the zone of reverse flow from the main stream flow.

Carey (1969) and Hickin (1978) also noted the association between

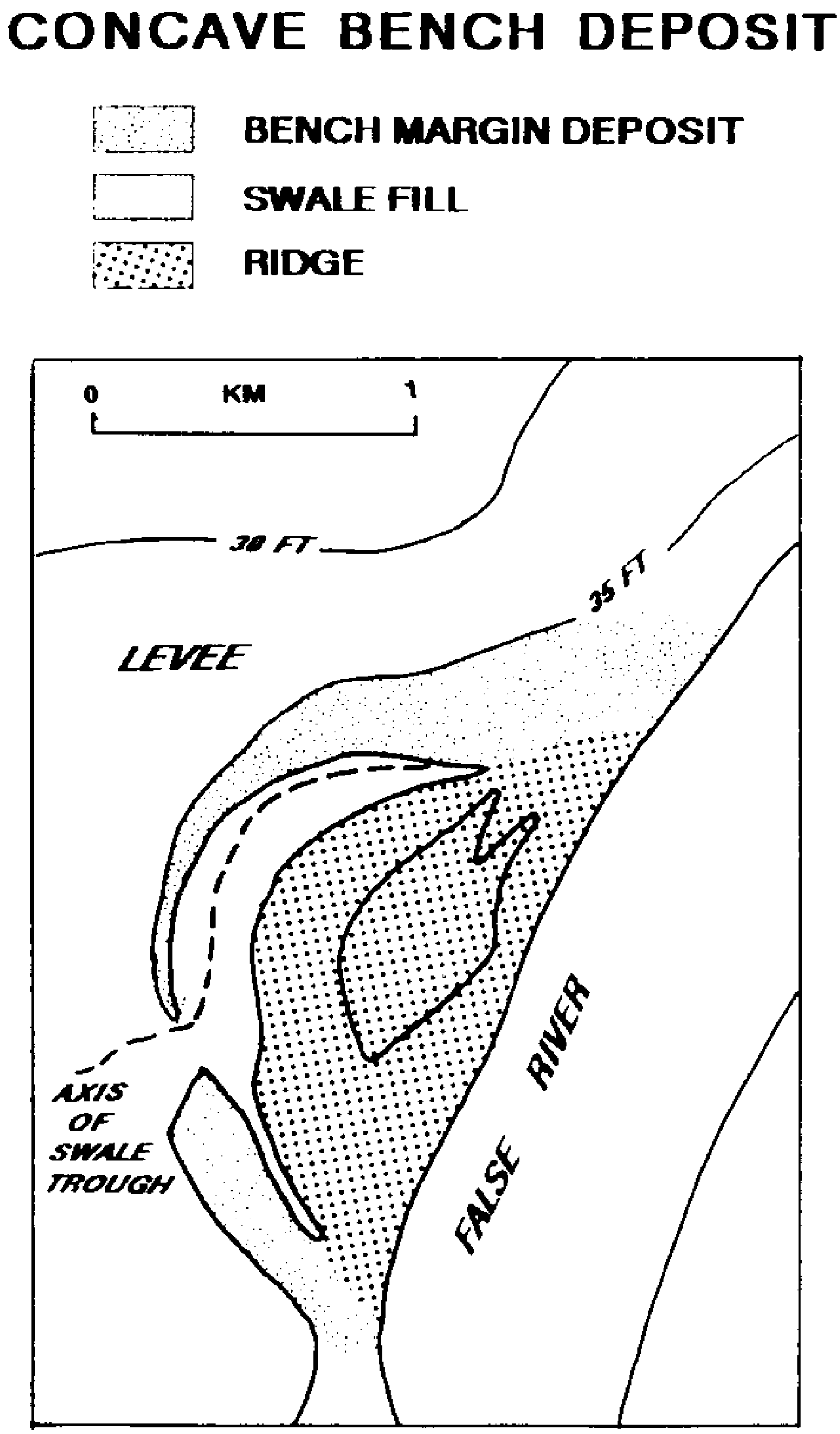
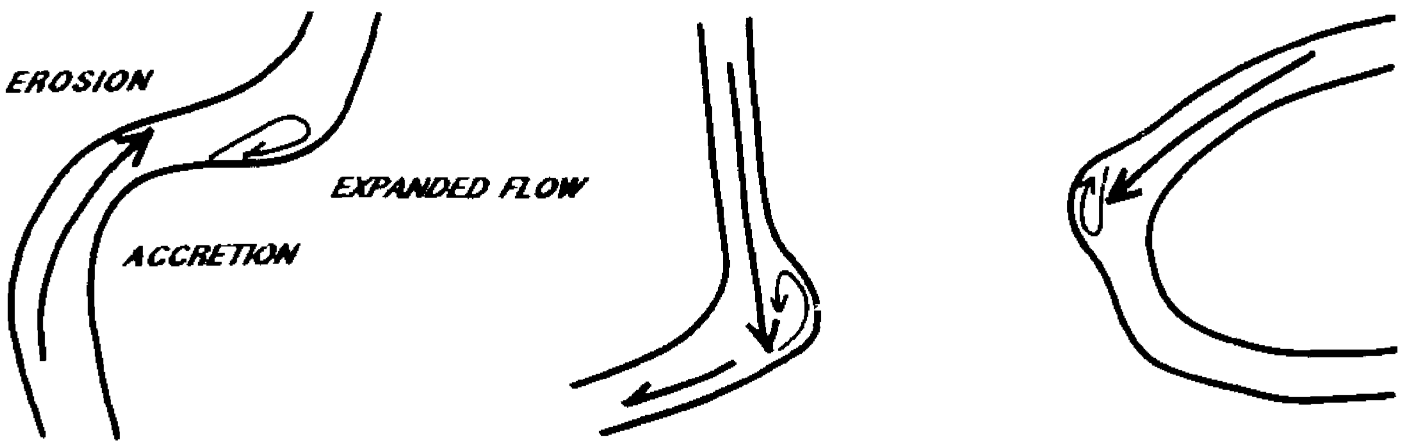


Fig. 8- Topography of the concave bench. 35 FT and 30 FT contours are shown. The bench deposits are divided morphologically into 1) swale, 2) bench margin, and 3) ridge deposits.

FLOW SEPARATION ZONES AND THE FORMATION OF CONCAVE BENCHES



A. DOWNSTREAM FROM POINT BAR. NANSON AND PAGE, 1983.

B. AT ABRUPT - ANGLE TURNS. CAREY, 1969.

C. ALONG CONCAVE BANK IN TIGHTLY CURVING MEANDER BENDS. CAREY, 1969; HICKIN, 1979.

Fig. 9- Origin of concave benches.

tightly curving meander bends with small radii of curvature and the formation of concave benches. In tightly-curving meander bends such as the False River meander loop, the main stream flow can impinge against the concave side of the meander loop as it rounds the bend out of a straight reach. When this happens the stream flow probably directly erodes an indentation into the bank (Fig. 9) and the zone of reverse flow would be a direct consequence of the formation of the indentation.

Carey (1963, 1969) noted that abrupt angle turns and tightly curved meander loops in the Mississippi River are often coincident with channel (or meander belt) segments that impinge on erosion resistant substrate that inhibit the river from migrating freely. The False River region lies along a segment of meander belt that is confined by the valley wall along its eastern margin and flood basin clays along it western margin.

Depending on local conditions the flow separation zone may form either concave-bench accretion deposits (terminology from Nanson and Page, 1983) on the upstream shore or a single bar-like island within the vortex of the separation zone itself (Carey, 1969). Each island is separated from the 'mainland' by a narrow chute channel which may rapidly fill in (Carey, 1969). These islands are not 'tow-head' islands. Tow-head islands form when chute cutoffs separate a portion of a point bar from the mainland. The entire configuration including the impinging jet, flow separation zone and zone of erosion may migrate downstream (Carey, 1969).

Meandering History

Fisk (1944) inferred a meandering history for the Mississippi

River in the presently occupied channel belt based on orientation of ridges and swales on preserved point bars and the assumption that point bars migrate at a constant rate (Fisk, 1944, Plate 22, Sheet 14). The meander loop and its associated point bar migrated gradually southwestward in the study area between about 700 and 1500 A.D (Fig. 10A). Between Fisk's (1944, Plate 22, sheet 14) stages 9 and 12, the Mississippi River migrated at an average rate of about 8.5 to 15 m/year (28 to 50 ft/year) for this meander loop (see Appendix E for calculation) depending on the date used for the establishment of the channel belt.

Fisk (1947) believed that the odd slice of meander belt preserved on the flood basin side of False River was produced during progressive migration of the channel towards the southwest (Fig. 10). According to his calculations, the channel acquired a meander loop with a local small radius of curvature about 1500 A.D. Then a chute cut-off between 1500 and 1600 A.D. resulted in the preservation of the meander belt slice along the western side of the oxbow lake. Following this, historic records indicate that in approximately 1700 A.D., a neck cut-off resulted in the formation of False River, an oxbow lake (Fig. 10B) (Sternberg, 1956). Since that time the active channel thalweg has remained close to the eastern wall of the valley.

If Fisk's explanation is correct, False River is a chute cut-off and geomorphic evidence in the form of a relict channel that is about the same width of False River should be present along the western margin of the meander belt slice. There is no such evidence for a paleo-channel.

An alternative explanation is that this meander belt slice formed

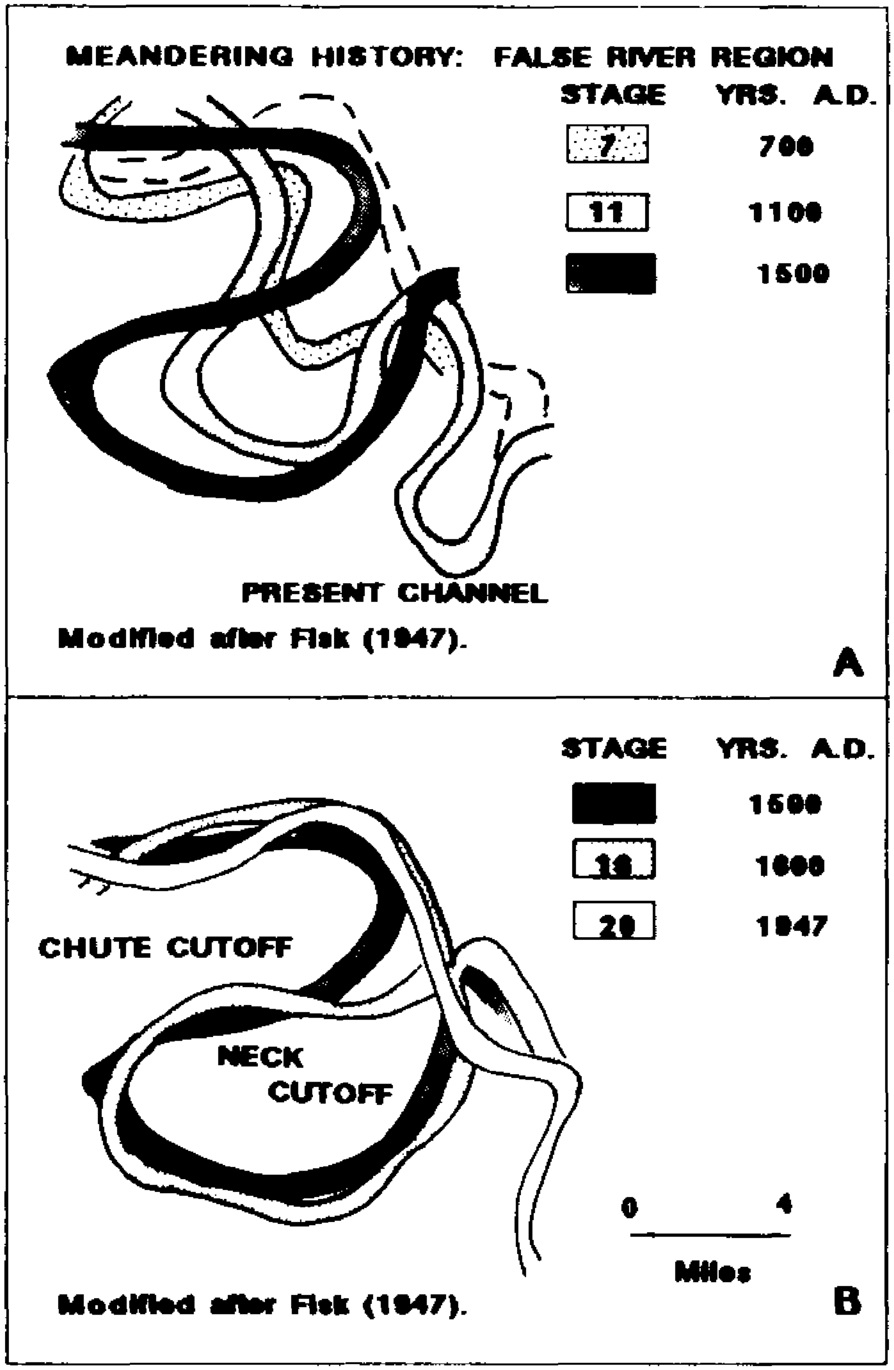


Fig. 10. Meandering history of the Mississippi River in the False River Region. A. from 700 A.D. to 1500 A.D. B. from 1500 A.D. to 1947 A.D. From Fisk, 1947.

as a concave bench deposit during an interval of time that preceeded the neck cut-off (1700 A.D.). It is morphologically similar in size, shape and ridge concavity (towards the main channel) to several other concave benches described by Carey (1969) near the False River study area. Point bar deposits have a similar ridge and swale topography but the ridges are convex towards the channel. This concave bench is different from those described by Carey (1969) because their deposits are not finer-grained than upper point bar deposits and because the concave bench ridges are similar in elevation to the ridges on the point bar side of the adjacent meanders.

CHAPTER 3. SAMPLING

INTRODUCTION

In this study of stratification in overbank environments, the approach used by Ray (1976) of examining a specific subenvironment (upper point bar) for flood-related sequences is combined with the Cross and Smith (1985) approach of sampling sub-environments with a large number of closely spaced cores.

Levee, splay, backswamp, upper point bar and concave bench deposits were cored with a Gidding's Rig. Crevasse channel fill was sampled using conventional vibracoring techniques (see Smith, 1984). Additional information was acquired from trenches and exposures of upper point bar deposits at Solitude and Thomas Points, both active point bars on the Mississippi River (Fig. 2).

CORING WITH A GIDDINGS RIG

Approximately 70 cores were collected with the Giddings Rig in sub-aerial environments including meander belt, backswamp, levee, and splay deposits (Fig. 6). These cores were taken in a Shelby tube (9 cm diameter X 1.14 m in length) lined with PVC tubing. This type of coring proceeded incrementally to a maximum penetration depth of 9 m as the shelby tube is hydraulically pushed into the ground by the probe truck. The upper 4 to 5 segments of core were generally in excellent condition but at depths greater than 5.5 m, scrapings from the walls of the core hole usually caused compaction and disruption of sedimentary structures in the upper 50 cm of each core tube.

VIBRACORING

Thirty-six vibracores were acquired from the subaqueous crevasse channels including 7 cores across a crevasse at a single site. Penetration depth was shallow (less than 3.5 m) because of the tightly packed backswamp and levee deposits occuring beneath the crevasse channel fill. For the most part, these crevasses were still unfilled and actively transporting water during periods of high water in False River. The vibracoring procedure is described by Lanesky et al (1979), Hoyt and Demarest (1981), and Smith (1984).

CORE PREPARATION

In the lab the cores were split, slabbed for X-ray radiography, described and photographed.

The PVC tubes holding the core were split longitudinally with a hand-held circular saw. Four slits were cut in each tube so that a 2 cm thick slab could be removed from the center of the core for X-ray radiography work. As each slit was cut it was taped back together with a strip of duct tape so that the core would remain intact while the 4 saw slits were being completed. This splitting method resulted in the partitioning of each core into three longitudinal segments which could easily be separated with piano wire. The middle rectangular slab of sediment was then trimmed to appropriate thickness (0.5 cm to 0.75 cm) and cut to appropriate length for X-ray radiography. The other two undisturbed core sections were used for visual description, photography and peels. Conventional methods of peeling the cores at ambient pressure (with epoxy or Elmer's glue) did not work because they were too fine-grained. Therefore, this method of study was abandoned.

The aluminum coring tubes (9 cm in diameter) were split longitudinally into only two sections because the aluminum tube deformed and destroyed the core when four slits were made. One of the core halves was extracted from the aluminum tube by allowing it to air dry for several hours. The extracted core was then slabbed to appropriate thickness for X-ray radiography. The other unextracted half of the core was saved for photographing and description.

X-RAY RADIOGRAPHY

Rectangular slabs with maximum lengths of 42 cm, widths of 14 cm and thicknesses between 0.5 and 0.75 cm were prepared for X-ray radiography. Kodak Ortho-M film, a type of medical X-ray film, was used in the X-ray radiograph studies because it could be automatically developed at the Campus Health Center in 90 seconds. Film with dimensions of 43 cm X 35 cm permitted 4 slabs with lengths of 42 cm to be irradiated simultaneously. Each sheet of film was held in a cardboard holder and placed under the sediment slabs. The film was exposed for 4 to 8 minutes at 40 kilovolts and 5 milliamps at a focal length of 60 cm.

CORE DESCRIPTION

Each of the cores was divided into a number of lithologically distinct units. Cross-sections were constructed by correlating these units along profiles.

CHAPTER 4. STRATIGRAPHY OF MEANDER BELT DEPOSITS

POINT BAR DEPOSITS

The Fining-Upard Sequence

Several data sources including Fisk (1944, 1947), Frazier and Osanik (1967), Ray (1976), Hayes (1985) and Farrell (this report) were used to construct a composite, fining-upward, stratigraphic section for a Mississippi River point bar (Fig. 11). This sequence extends from the base of the meander belt to the crest of an upper point bar ridge. A typical meander belt in the lower Mississippi Valley is about 30-40 m thick (Fig. 7) and 5-10 km wide (Fig. 2). The lower point bar is about 20-30 m thick. Above this, the upper point bar consists of about 8 m of ridge and swale deposits.

Lower Point Bar Deposits

Large-Scale Trough Cross-Stratified Sand-- The main stratification type in Mississippi River lower point bar deposits is highly monotonous large-scale trough cross-stratification in fine to medium grained sand (Hayes, 1985; Frazier and Osanik, 1967) (Fig. 12). This observation was initially reported by Frazier and Osanik (1967) who studied a 14 m deep excavation through lower point bar deposits at the Old River Locksite (a point bar complex approximately 40 km north of Solitude Point). They reported that the size of the cross-sets and grains is relatively constant over a vertical distance of 14 m.

From photographs and well logs of cores through channel belts, it is observed that approximately 2 m of gravelly, fine to medium grained sand are present at the base of the lower point bar sequence (I.B.Singh, personal communication). Pea-sized gravel lags are

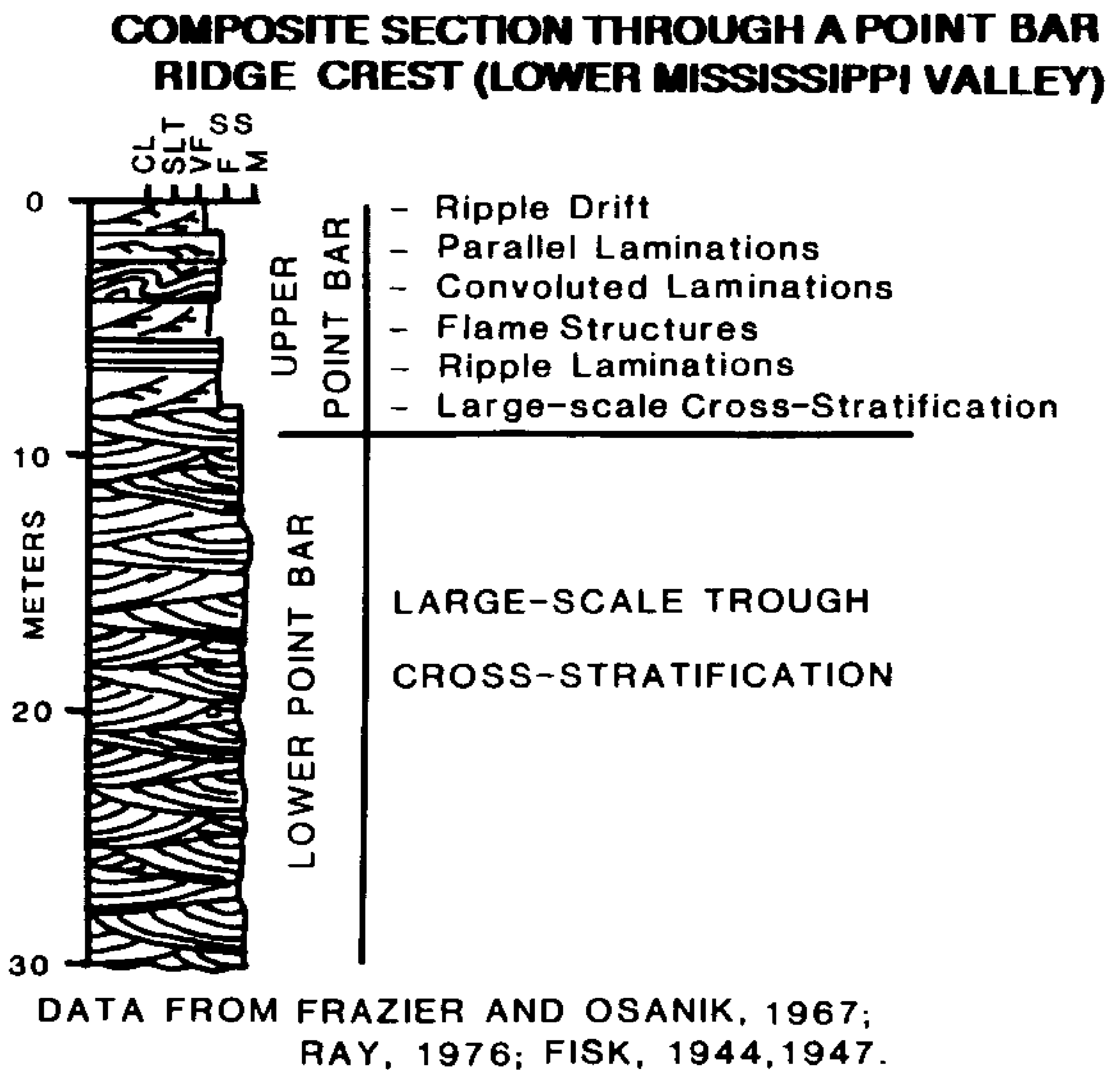


Fig. 11- Composite section (schematic) through a Mississippi River point bar showing fining-upward sequence and relationship between upper and lower point bar sub-environments. Data from Frazier and Osanik (1967), Ray (1976) and Fisk (1944, 1947).

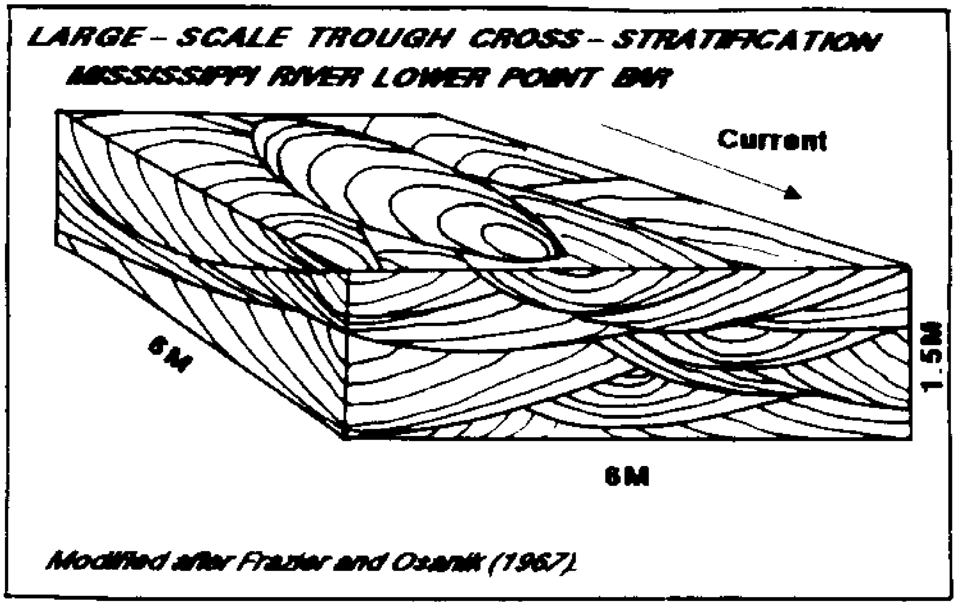


Fig. 12- Diagram showing dimensions of large-scale trough cross-stratification in lower point bar deposits at the Old River Locksite. Modified after Frazier and Osanik, 1967.

present at the bases of trough cross-sets or as sporadic avalanche laminae.

Figure 12 taken from Frazier and Osanik (1967), shows the typical dimensions of these trough cross-sets. The sand was well-sorted and fine to medium in size. Maximum observed cross-set thickness was about 60 cm and foreset laminae dipped downstream. Particulate organic debris such as coffee grounds and wood fragment concentrates occurred locally along set boundaries and also in some of the foreset laminae. This bedding is the result of scour and fill caused by the migration of 3-dimensional megaripples downstream across the point bar (Hayes, 1985).

Large-scale planar cross-laminated sand-- On subaerial parts of the lower point bar platform which is exposed at low water, Hayes (1985) observed that planar cross-laminated sands overlie the large-scale trough cross-stratified sands. He found that individual cross-sets have a maximum thickness of about 0.5 m. Individual foresets are about 3 cm thick and fine upward. Arrangements of bounding surfaces and dimensions of cross-sets are shown in Figure 13.

Small-scale cross-laminated sand-- Several types of small-scale cross-stratification and ripple laminated sets form thin superficial highly variable deposits on the surface of the lower point bar. Some small-scale trough cross-sets closely resemble the elongate trough-shaped erosion scars filled with sediment described by Ray (1976). Generally these bedforms are 1 cm in height and 4 cm in length. Other types are planar cross-stratified sets about 1-2 cm in thickness. These strata are mainly the result of reworking by currents during falling water stages and runoff waters at low water stage. Where observed in a stratigraphic sequence they probably indicate sub-aerial exposure of the lower point bar platform.

Upper Point Bar Deposits

Ray (1976) found that the main stratification types in upper point bar deposits are: ripple-drift cross-stratification, parallel laminations, convoluted laminations, flame structures, and small-scale trough cross-stratification in silt to fine sand.

My own observations in trenches through ridge crests on active point bars reaffirm Ray's (1976) observations. The ridges consist of

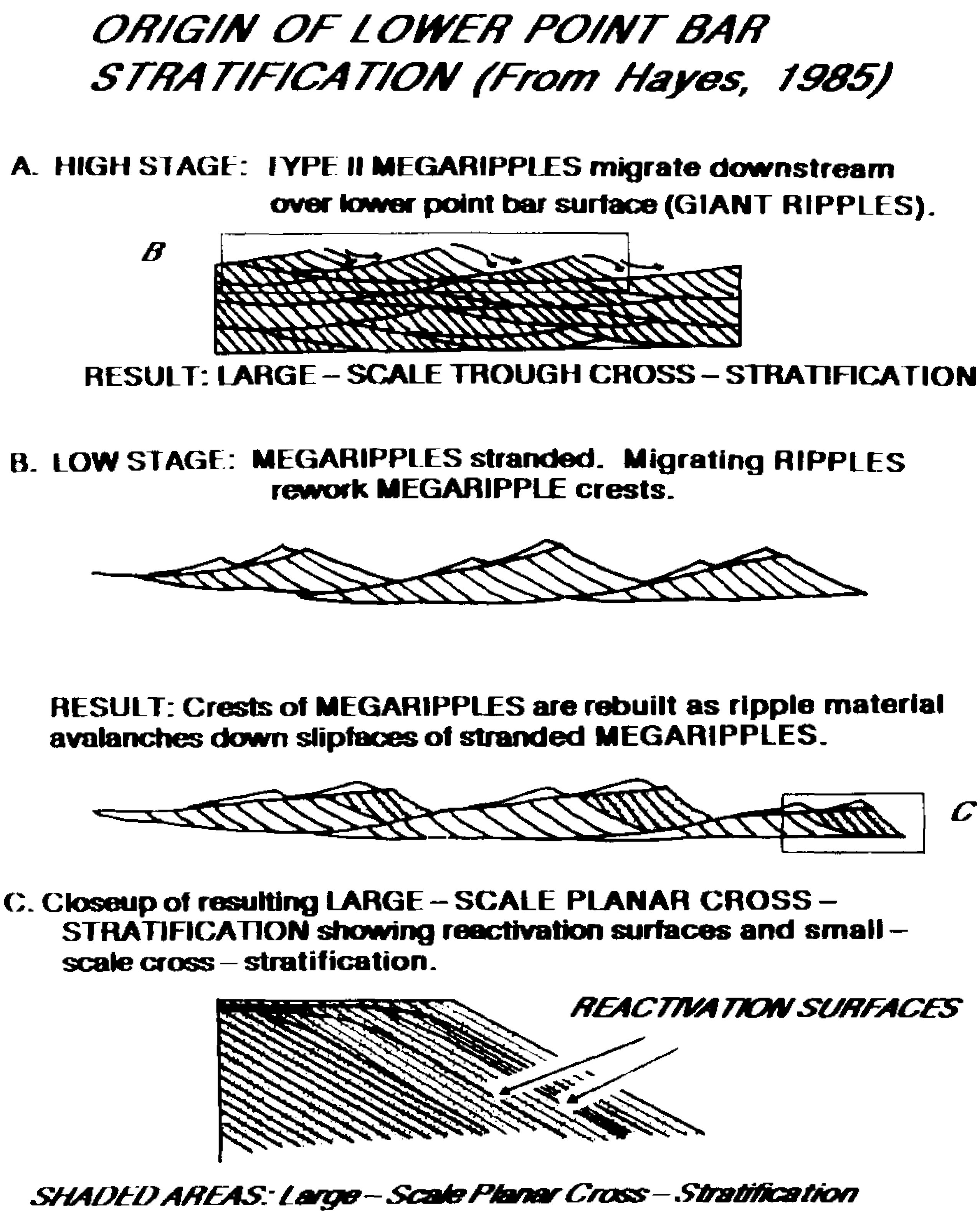


Fig. 13- Origin of lower point bar stratification. Modified after Hayes, 1985.

a core of interbedded ripple-drift cross-stratified sand and parallel laminated sand (Fig. 14A, 14B). Small-scale cross-laminated sand is present locally as a surficial phenomemon. Flame structures, and convoluted laminations are observed as local variants of parallel laminated sand beds. All bedding types occur in very fine to fine grained sand and coarse silt.

The beds of ripple-drift cross-stratified sand and parallel-laminated sand which make up the core of the ridge overlie and interfinger with the large-scale trough cross-stratified sands of the lower point bar near the toe of the ridge slope (Figs. 15, 14D). On the thalweg side of the ridge, these beds dip toward the channel (Fig. 15). Ray (1976) also shows units dipping towards the channel in a trench presumably oriented orthogonal to a ridge crest. In some trenches, there is also a downstream component of dip of these beds with respect to the ridge axis (Fig. 16). This may indicate that the beds were both laterally and longitudinally accreted in a downstream direction along the ridge margin with respect to the main stream flow direction.

The channel side of the first ridge is usually scarped by wave erosion at falling water levels towards the end of a flood season. Scarps are also preserved internally in the ridges (Fig. 15B). They are recognized as vertically truncated beds overlain by younger lateral accretion units. Intraclasts of clay and hanging layers of undercut clay are associated with the scarps.

Ripple drift cross-stratified sand-- All four types of ripple drift cross stratification (Jopling and Walker, 1968) are present in the ridge deposits of the upper point bar. However, the thickest

Fig. 14- Stratification in upper point bar ridge deposits.

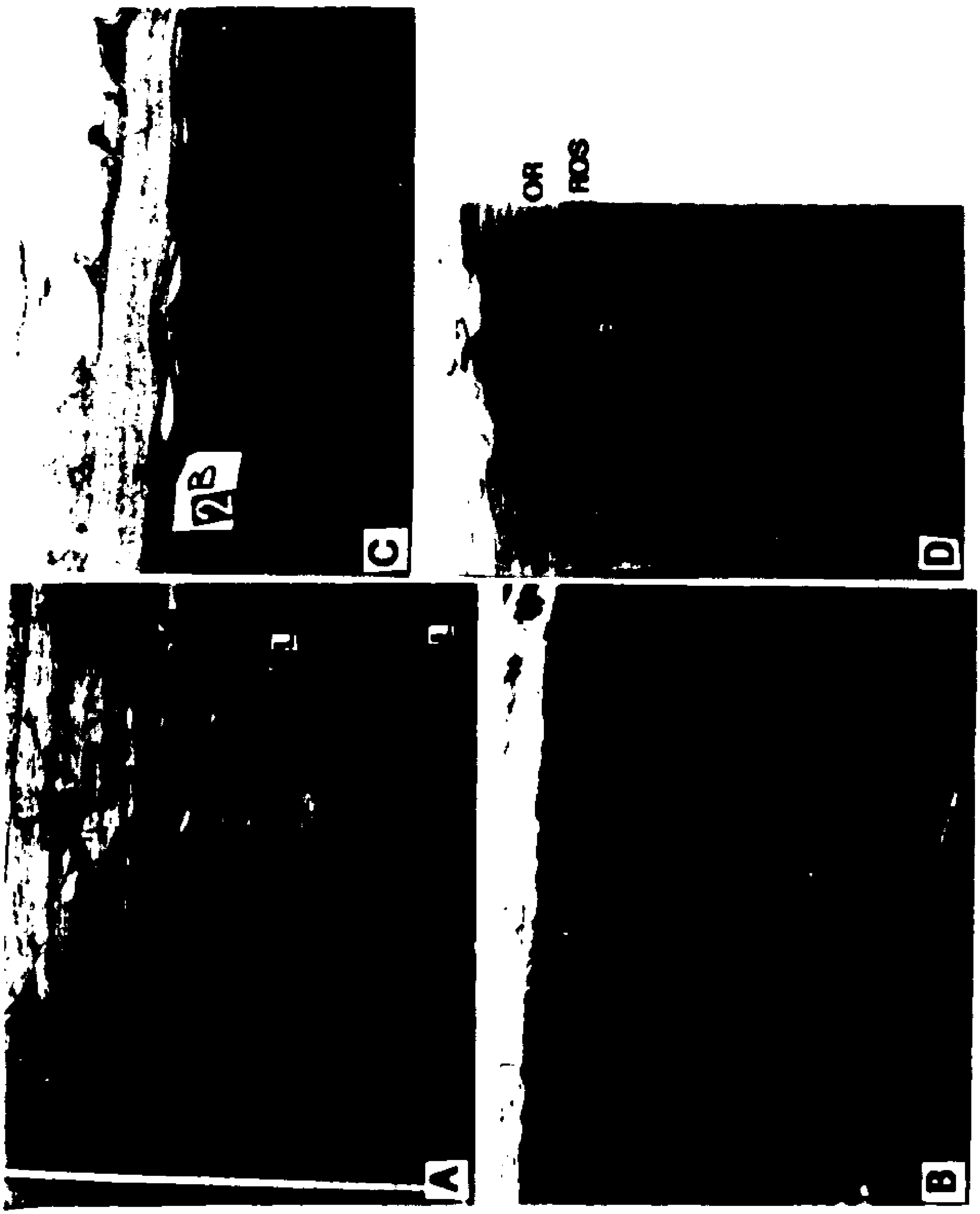
(See photographs on next page).

A. Gradational sets of ripple drift cross-laminations and parallel laminations. The dark layers (L) consist of a mixture of organic debris, mainly leaves, and sediment. A single flood "cyclothem" lies between the lower and upper leaf horizons (L). Downstream is to the left. The exposure is parallel to the ridge crest.

B. Complexly interlayered ripple-drift (?) and parallel laminations (?). The ridge crest is approximately parallel to the outcrop. Downstream is to the right. At this location the ridge may have behaved as a transverse bar. If this is the case, this bedding may represent the slip face of a large bedform where backflow ripples formed in the flow separation bubble.

C. Laminated sands draping ripple forms. Note convoluted silt with flame structures at the top of the laminated bed.

D. Laminated sands overlying trough-cross sets of the underlying lower point bar. Note truncated oscillation ripples (OR) and vertically laminated rip-up clasts (ROS).


C
2B
OR
ROS
D
A
B

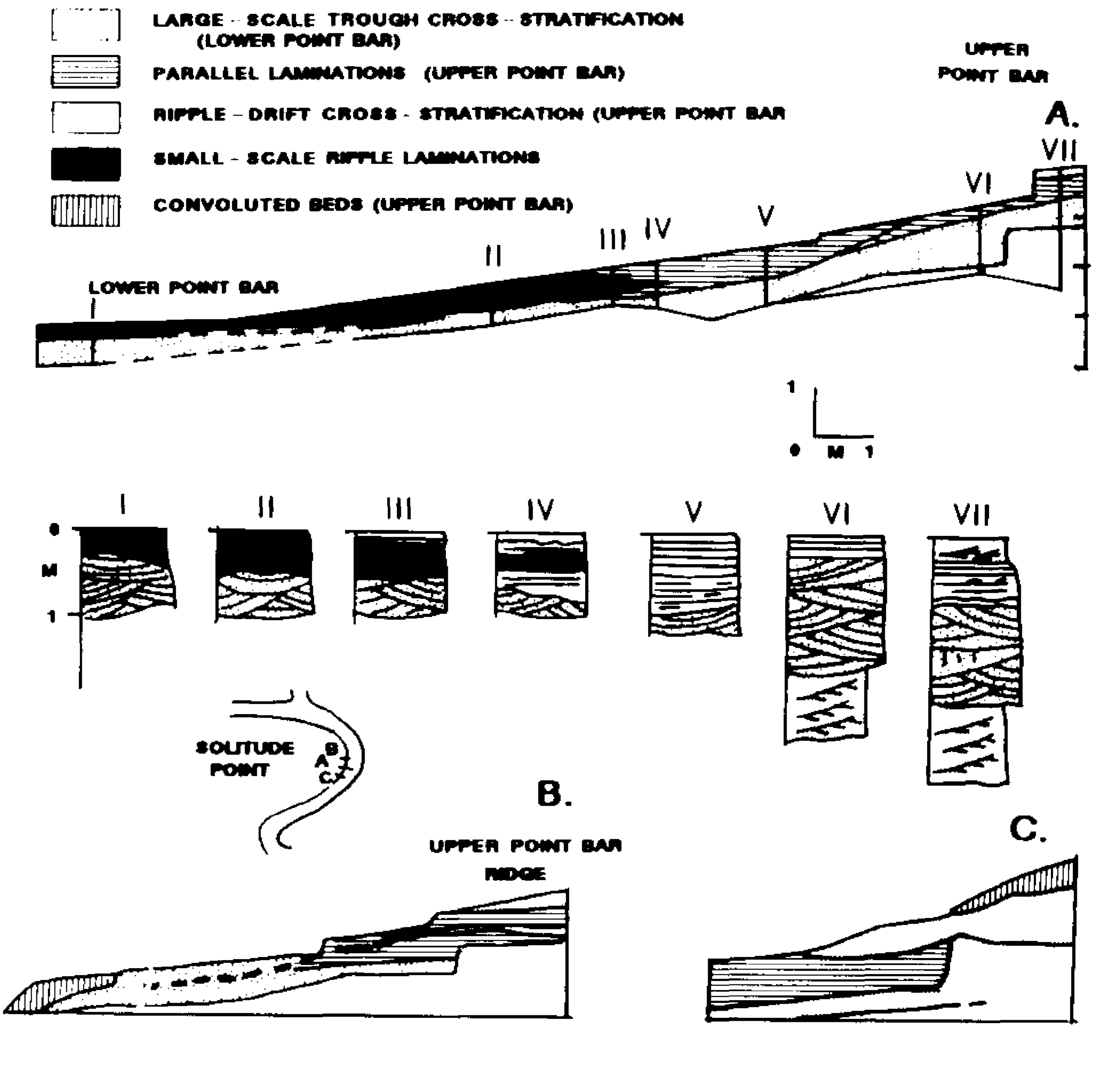


Fig. 15- Trench data from upper point bar deposits at Solitude Point. Trenches A, B, and C are oriented orthogonally to the first ridge crest of the upper point bar.

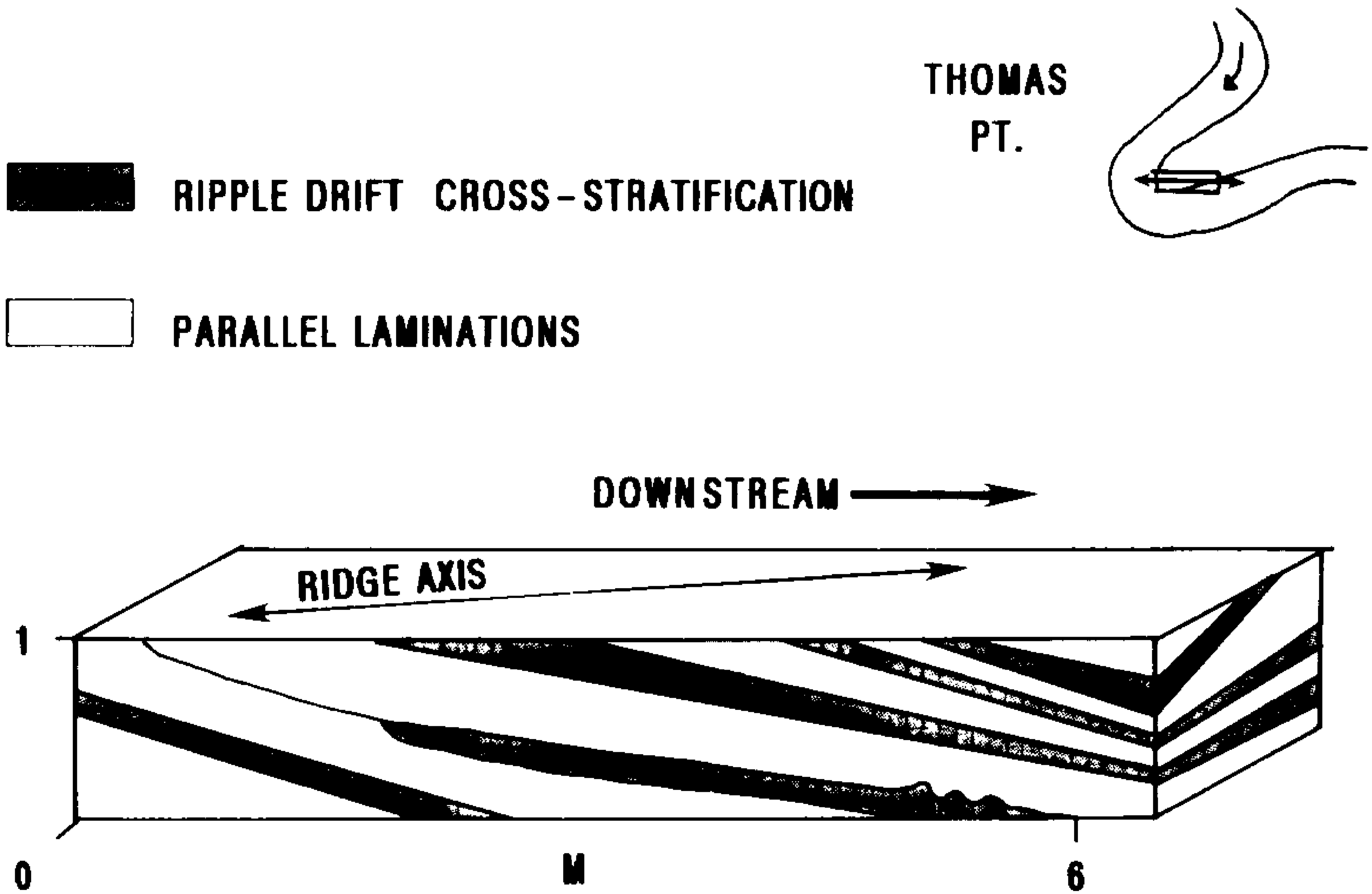
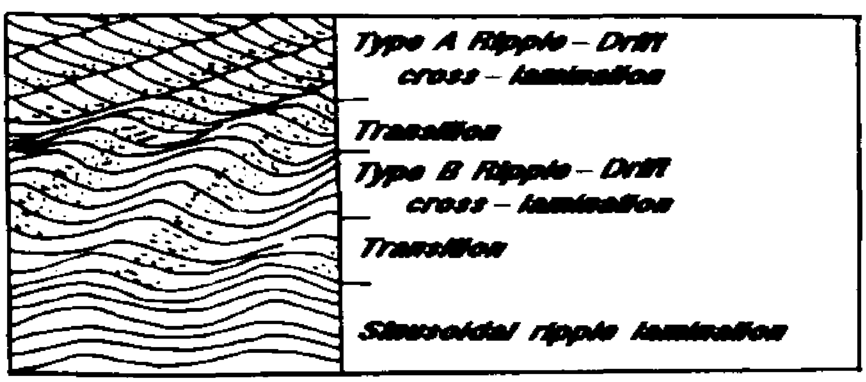


Fig. 16- Three dimensional view of bedding shown in ridge deposit (Fig. 18B). Axis of ridge is parallel to arrow. Downstream is to the right. Sketch above shows map view of Thomas Point and approximate location of trench.

units consist of Types A and B and transitional (A/B) forms. Cosets range in thickness from 10 cm to 60 cm. An example of ripple-drift climbing downstream parallel to a ridge crest is shown in Figure 14A. Other very complex patterns of ripple drift (Fig. 14B) appear to climb upstream parallel to the ridge crest.

Vertically adjacent beds of ripple drift cross-laminated sand and parallel laminated sand are separated by 1) gradational contacts, 2) erosional contacts, 3) macerated leaves and plant debris or 4) clay layers.

Ideal 'flood cyclothems' deposited during a single flood have been described by Nanson (1980) and Ray (1976). A gradation in bedding, lacking internal discontinuities, from sinusoidal ripples to Type A ripple-drift cross-stratification (Fig. 17) represents increasing bedload movement relative to fall out of grains from suspension (Jopling and Walker, 1968). This is caused by a gradual change in



From Jopling and Walker, 1968.

Fig. 17- Sketch showing the gradation in bedforms that exists between sinusoidal ripple laminations and ripple-drift cross-stratification. From Jopling and Walker, 1968.

stream power or flow regime. Sharp, erosional contacts may be generated at the beginning of a flood stage by rising flood waters or by the passage of turbulent eddies during a flood.

Normally, individual flood cycles are not recognized unless layers of macerated leaves and plant debris and/or clay separate beds. Clay layers represent suspension sedimentation from water ponded at the end of a flood cycle. Layers of plant and organic debris probably originate as a drape over pre-existing deposits as the water table in a ponded area drops below the ground surface as the flood stage lowers. They may also represent erosional lag deposits at the base of the superadjacent flood cycle. Gestaldo et al (1987) believe that these layers originate as drapes at the end of a flood cycle, protect the underlying sediment during the next flood, but are partially reactivated as lags by the rising flood waters.

An example of stratification in a scroll-bar along an exposure parallel to a ridge crest is shown in Figure 14A. A bed of Type A ripple-drift which climbs downstream overlies a thin bed of dark colored macerated leaves and organic debris mixed with fine-medium sand. Symmetrical ripple forms are preserved at the top of the ripple drift. These ripple forms are draped by laminations which pass upsection into parallel laminations. The parallel laminated bed is topped by a second layer of macerated leaf debris which marks the boundary between two flood cycles.

The two layers with leaf debris accummulated near the end of two flood cycles. The strata between the two leaf layers was deposited during a single flood because the stratification is internally gradational. The lower layer of organic debris was probably partially reactiviated during the rising of the next flood. The bed of ripple-drift was probably deposited at the height of flood activity. The transition in bedding from ripple drift to parallel laminations upsection probably indicates a decrease in flow regime since the ripple forms are preserved at the top of the bed. As the high rate of sedimentation fell during the waning of the flood, ripple forms were stranded and sand continued to be deposited as suspension drapes. A continued lowering of flow regime buried the ripple forms and parallel laminations were emplaced. An increase in flow regime would probably have truncated these ripple forms. The second layer of organic debris was deposited at the end of the flood as a drape.

A second trench showed multiple units of ripple-drift cross-stratification grading into parallel laminations (Fig. 14B). The dark-colored layers exhibit ripple-drift and the light layers are parallel laminated. Convoluted laminations with flame structures are present at the top of the trench. The flames point downslope and towards the thalweg. These beds are oriented obliquely to the ridge axis (Fig. 16). They dip downstream and toward the channel. The direction of climb, however, appears to be upstream.

The gradational nature of the contacts described above indicates that all beds were deposited over the same flood cycle and that the flow regime fluctuated many times. Due to the orientation of the meander loop with respect to the ridge axis at this particular trench locality (Thompson Point), flow at the highest water stage flowed from the upper point bar towards the lower point bar. Figure 18 shows schematically how water flows over this point bar depending on river stage.

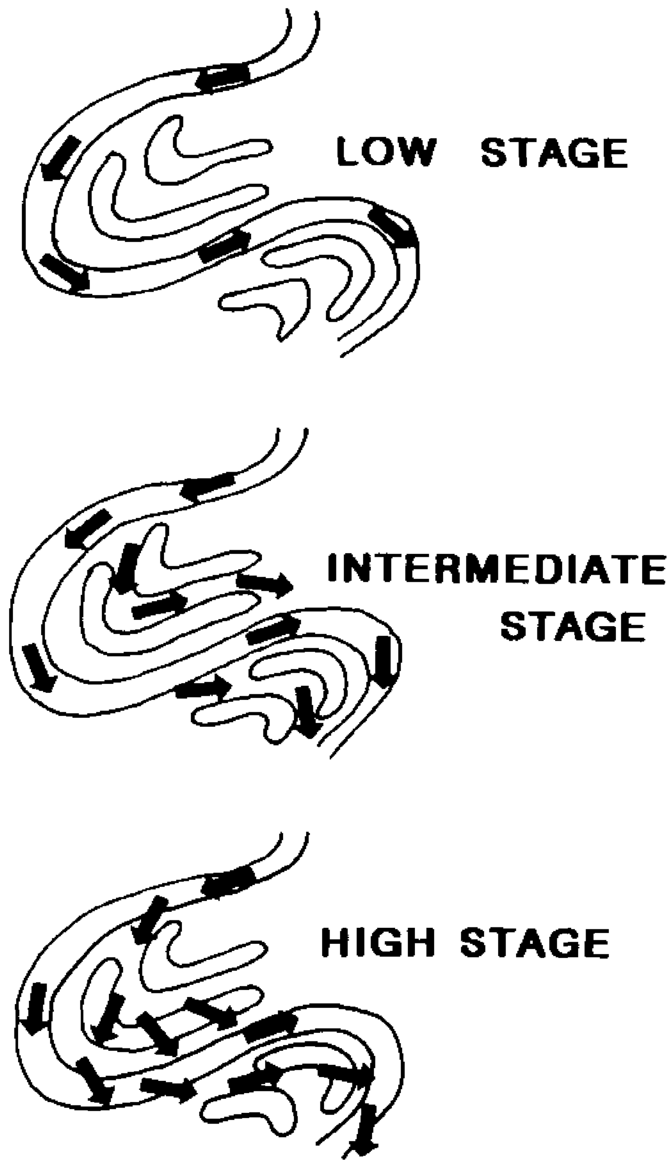


Fig. 18- Schematic diagram showing the flow of river water with respect to the upper point bar ridges at low, intermediate and high flow. Ideas from Jackson, 1975 and Singh, personal communication.

Parallel Laminated Sand-- Parallel laminated sand occurs interbedded with ripple-drift cross-stratification as described above. However, it is also commonly present as surficial beach-like deposits along the scarped margin of ridges or in the subsurface of ridges interbedded with units exhibiting ripple drift. In beach-like deposits, the laminations consist of alternating layers of fine to very fine sand and brownish-gray silt composed of organic detritus and heavy minerals (Fig. 14C, 14D). Individual laminations are up to several mm thick. These laminations are bundled together into sets about 10 to 30 cm thick which dip toward the channel at an angle of about 7 degrees. Each bed truncates underlying strata. Upslope the beds pinch out, commonly at the toe of scarps. In a downslope direction beds thicken and the laminations are truncated by the next overlying bed. These beds exhibit offlap with respect to underlying beds (Fig. 19) because they were emplaced as a series of prograding beach-like deposits or swash zones on the scarped benches of the ridge margin during falling water levels.

These parallel-laminated beds also exhibit a number of other sedimentary structures which indicate upper flow regime conditions in a swash zone along inclined bedding surfaces. Washed-out symmetrical oscillation ripples or sinusoidal ripples with heavy mineral drapes in the troughs are present within or at the top of some of the laminated beds (Fig. 14C). These ripples formed by wave activity in the swash zone. The transition from parallel laminations to symmetrical ripples in a single set indicates that the beach is migrating downslope.

Soft sediment deformation features such as convoluted bedding,

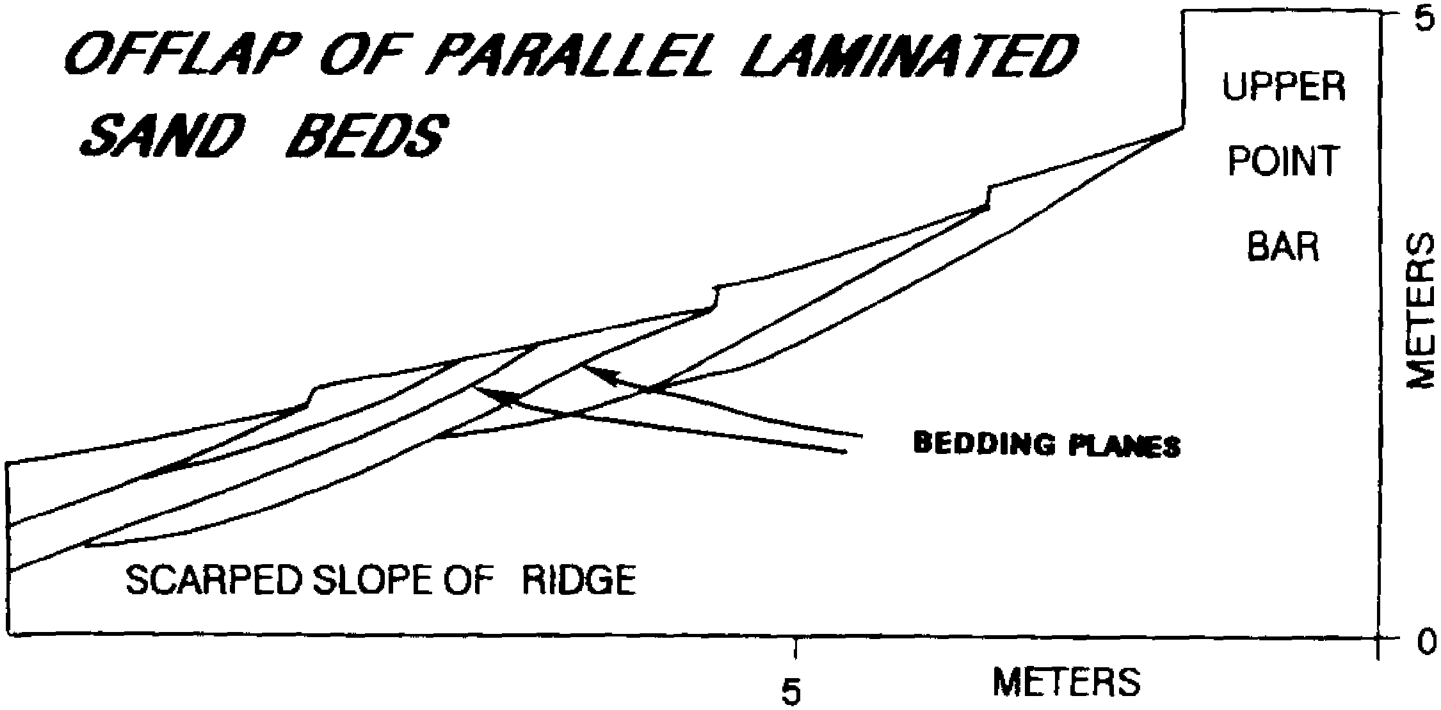


Fig. 19- Offlap in parallel laminated sand beds in ridge deposits.

flame structures (Fig. 14C) and very small-scale nappe structures (Fig. 14D) are common. Convoluted laminations exhibit small folds with amplitudes of 3-4 cm and wavelengths of 6-10 cm. Flame structures often occur as sharp anticlinal features (Type II convoluted laminations of Ray, 1976) which are inclined downslope in trenches, towards the river. Deformation is usually localized in outcrop to horizontal distances of 0.5 m. Deformation is probably due to both loading of fine sand over organic-rich silt and to dewatering.

The small-scale nappe structures are isolated pods of sediment approximately 2 cm in height by 20 cm in length which contain near-vertical laminations of fine light sand and organic-rich silt (Fig. 14D). Both the tops and bottoms of the internal laminations are truncated. The pods of sediment probably represent cross-sections through remnants of recumbent or overturned folds within convoluted beds which have slid downslope along the margin of the ridge.

The parallel laminated beds and the stratification features described above are upper flow regime in origin, produced in a gravitationally unstable inclined swash zone on the edge of the point bar during falling water stages.

Small-scale cross laminated sand-- Small-scale cross-laminated sand beds are not extensive in ridge deposits.

Genesis of Lower Point Bar Deposits

Hayes (1985) observed three superimposed bedform types on the subaerial part of the lower point bar platform at Solitude Point (Fig. 20): 1) giant, two-dimensional asymmetrical ripples (wavelength = 300-1000 m, height = 2-6 m), 2) Type II, three-dimensional, asymmetrical megaripples (wavelength = 10-30 m, height = 1m, and 3)

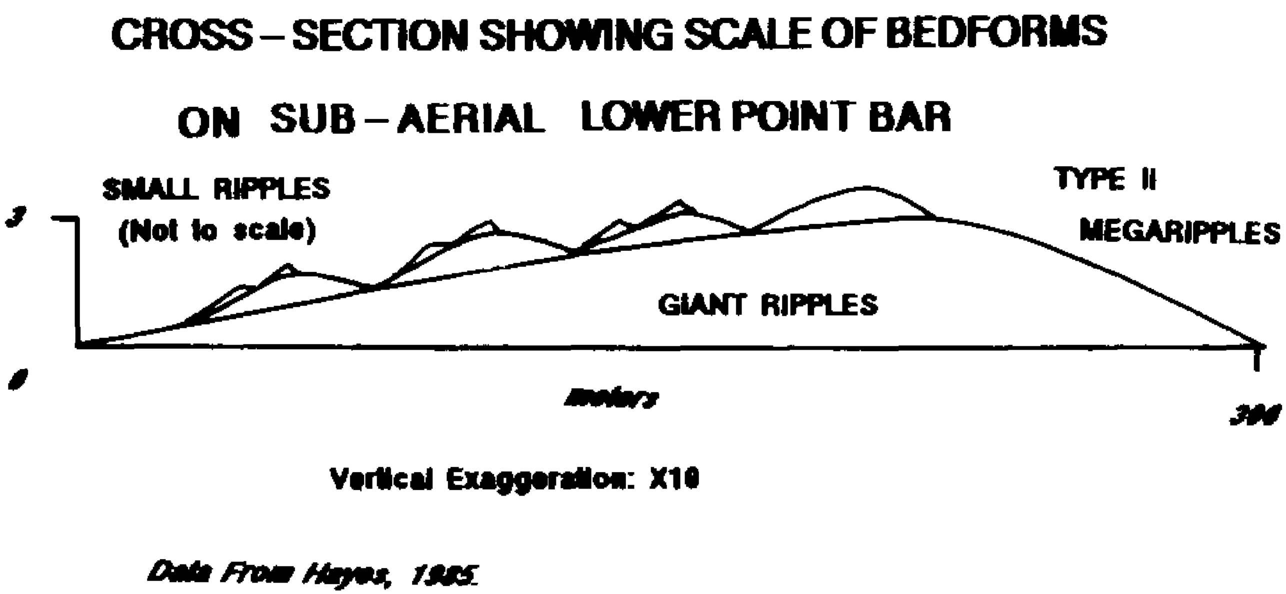


Fig. 20- Cross-section showing scale of bedforms on sub-aerial lower point bar (at Solitude Point. From Hayes, 1985.

small, three-dimensional asymmetric ripples (wavelength = 0.6 m, height = .06 m) (classification after Reineck and Singh, 1980).

According to Hayes (1985) the following sequence of events causes the stratification in lower point bar deposits (Fig. 13). During high water stages, large three-dimensional megaripples migrate downstream over the giant ripples. This results in the emplacement of trough cross-stratification (Fig. 13A) which is the main stratification type of the lower point bar. During falling water stages the large three-dimensional megaripples become inactive and are stranded on the lower point bar. However, smaller, three-dimensional ripples become active on the stoss sides of the stranded megaripples (Fig. 13B). These smaller ripples scour off the inactive megaripple crest and migrate downstream. When the ripples reach the stranded slip face of the inactive megaripple, the ripples cascade downslope to form a new set of foreset laminations. These foreset laminations according to Hayes (1985) are part of a set of planar cross-sets. Reactivation surfaces which separate sets of planar cross-stratification may form from pulses in current activity and sediment transport (Fig. 13B, 13C).

As a result, the lower point bar surface locally consists of a surficial planar cross-stratified sand overlying trough cross-stratified sand. The small-scale ripple laminated sets may also be present as thin surficial deposits. These represent ripple migration and a reworking of the underlying strata by currents and runoff during falling water levels. Hayes (1985) concluded that the planar cross-stratification and small-scale cross-stratification are destroyed by subsequent high water levels since it is not commonly observed in ancient point bar sequences.

Genesis of Upper Point Bar Deposits

Several different processes operate together to form the upper point bar accretion topography. These processes include lateral migration of the channel, the addition of longitudinal bars (scroll-bars) to the upper point bar and modification by overbank flooding.

In unconfined channels, meander bends migrate as laterally accreted beds are added to the leading edge of the migrating point bar. According to Fisk (1947), each ridge or scroll-bar forms as a longitudinal bar that accretes in an upstream direction over the lower point bar surface. Each bar is ultimately added onto the upper point bar (Fisk, 1947) as the channel migrates. It is not possible to observe this sequence of events on the lower Mississippi River today because the river is confined by artificial levees. My own data on the stratification in the ridges does not support this origin. Most beds of ripple drift climb downstream and indicate that the ridges were constructed by accreting in a downstream direction.

An alternative explanation which is supported by my stratification data is presented by Nanson (1980). According to his model (Fig. 21) scroll bars initially form as longitudinal bars which accrete downstream over the lower point bar platform. If the rate of cutbank erosion exceeds the rate of point bar migration in a meander bend, then a flow separation zone may develop along the point bar side of the stream (Fig. 21). Sediment-charged eddies move across the shear zone from the main stream into the flow separation zone. Most of the sediment is deposited near the outer boundary of the flow separation

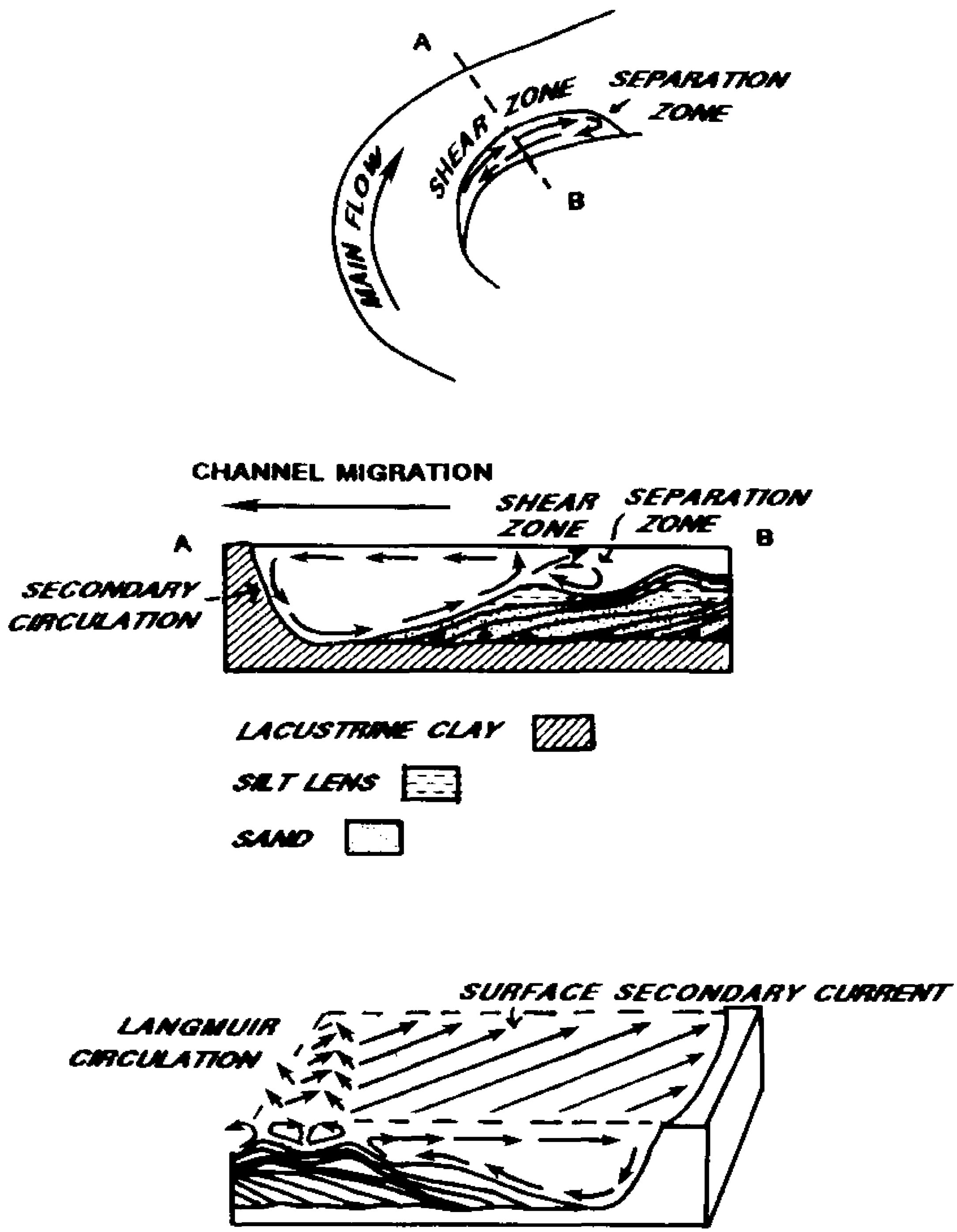


Fig. 21- The origin of scroll bars according to Nanson, 1980.

zone (Fig. 21). A ridge or scroll-bar of sediment is left near this boundary when flood waters recede. Paleocurrent vectors may converge downstream on both sides of the initial scroll-bar crest (Fig. 21).

This sedimentation process explains the orientation of the beds internal to the scroll bar, dipping with a downstream component and a component that dips towards the channel (on the channel side of the scroll bar). Presumably, on the swale side of each scroll bar, the beds dip downstream and towards the swale side of the scroll-bar if "Langmuir circulation" is set up.

During flood stage, a scroll-bar accretes downstream as inter-gradational sets of ripple-drift cross-laminations and parallel laminations are emplaced. As water rises and falls over the point bar a 'flood cyclothem' may be emplaced (Nanson, 1980). This cyclothem should grade in succession from basal plane-bedded silts up into Type B and then Type A ripple drift during a rising flood stage. At the flood peak scoured surfaces and trough cross-laminations should form. As the flood wanes, the reverse sequence is expected with the ultimate return to plane bedding. Complete flood cyclothems would be rare. Thick layers or organic debris such as leaves or clay layers help to delimit flood cycles. During falling water the channel-side of the scroll-bar is reworked into beach deposits and locally scarps may form.

When the scroll-bar or ridge adjacent to the channel achieves a high enough elevation it functions as the convex bank during flood stage. At very high water, flow may overtop the scroll bar which is acting as the convex bank. During flood stage, flood waters also enter the swales between the scroll bars. As a result of this overbank flooding, the ridges (scroll bars) and swales of the upper point bar are modified by overbank erosion and deposition.

The swale develops as a natural consequence of ridge accretion. During and immediately after ridge formation flood waters would flow at fairly high velocities through the swale, probably scouring it or depositing sediment as 'chute-fill'. Eventually the swale would become partially blocked by a sediment plug and would behave like an abandoned channel receiving largely sediment from suspension.

Several other points to consider are: during flood stages, 1) the entire ridge can act as a giant transverse bar with a separation eddy on the lee side of the ridge, 2) currents can flow either parallel or obliquely to ridges, and 3) oblique currents can flow from the swale side of the ridge towards the main stream or vice versa.

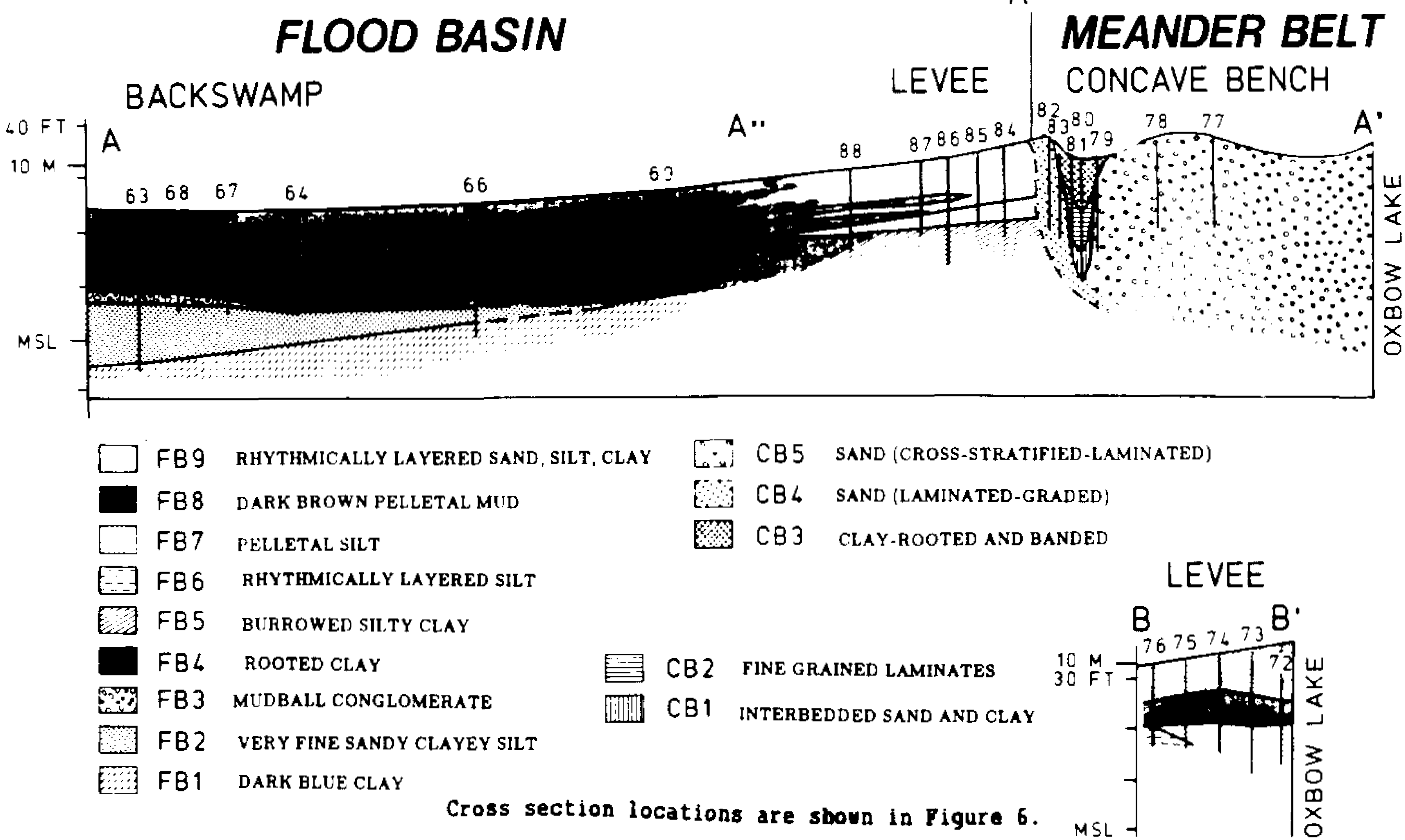
CONCAVE BENCH DEPOSITS

Distribution of Units

The concave bench forms an arcuate indentation in the natural levee (Fig. 6, 8). Geomorphically, the bench can be divided into three zones: 1) bench margin, 2) swale, and 3) an island-like ridge (Fig. 8). These divisions are based on the topography and lithology of the deposits. The swale-fill is primarily clay while the bench margin and ridge deposits are sand. The bench margin deposits are differentiated from levee deposits based on stratification. Traces of a second narrow swale are indicated by the indentation in the 35 ft. contour line in the center of the ridge.

A sharp contact exists between flood basin deposits and concave bench deposits (Fig. 22). The elevation of the base of the swale fill

Fig. 22. Profile A-A'. Extends across meander belt margin and includes concave bench, levee and backswamp deposits. Profile B-B. Includes Proximal levee deposits.



Cross section locations are shown in Figure 6.

indicates that this contact extends to a minimum depth of about 8 m. The actual depth to the base of the concave bench may be as great as 30 or 40 m, the total thickness of the meander belt. Presumably a paleo-cutbank excavated during the formation of the concave bench lies between the levee deposits of the flood basin and the first core through the bench margin deposit. This contact is probably nearly vertical in orientation at shallow depths (less than 8 m). Below this it either forms a horizontal bench-like surface that extends eastward or it slopes downward towards the paleochannel. The contact may be slumped.

Five units are observed in cores through the concave bench deposits (Fig. 23). The bench margin unit (CB4) consists mainly of sand with graded layers and parallel laminations. The ridge deposit (Unit CB5) consists mainly of interbedded ripple-drift cross-stratified sand and parallel laminated sand. The swale fill is divisible into into three clay-rich units (CB1, CB2 and CB3) which drape the floor of the swale and overlie the bench margin and ridge deposits.

Swale Fill Units

The swale fill is divisible into three units: 1) a lower sand and clay (CB1), an intermediate zone of laminates (CB2), and upper rooted unit (CB3) (Fig. 23, 24).

CB1-- The basal unit of the swale fill consists of fine-grained, well-sorted sand interbedded with laminated clay (Fig. 24, 25G, 25H). Each of the sand beds is less than 40 cm thick. The laminated clay interbeds are less than 20 cm thick.

The lowest sand bed is parallel laminated (Fig. 25G, 25H) and is partially disturbed either by vertically burrowing organisms or roots.

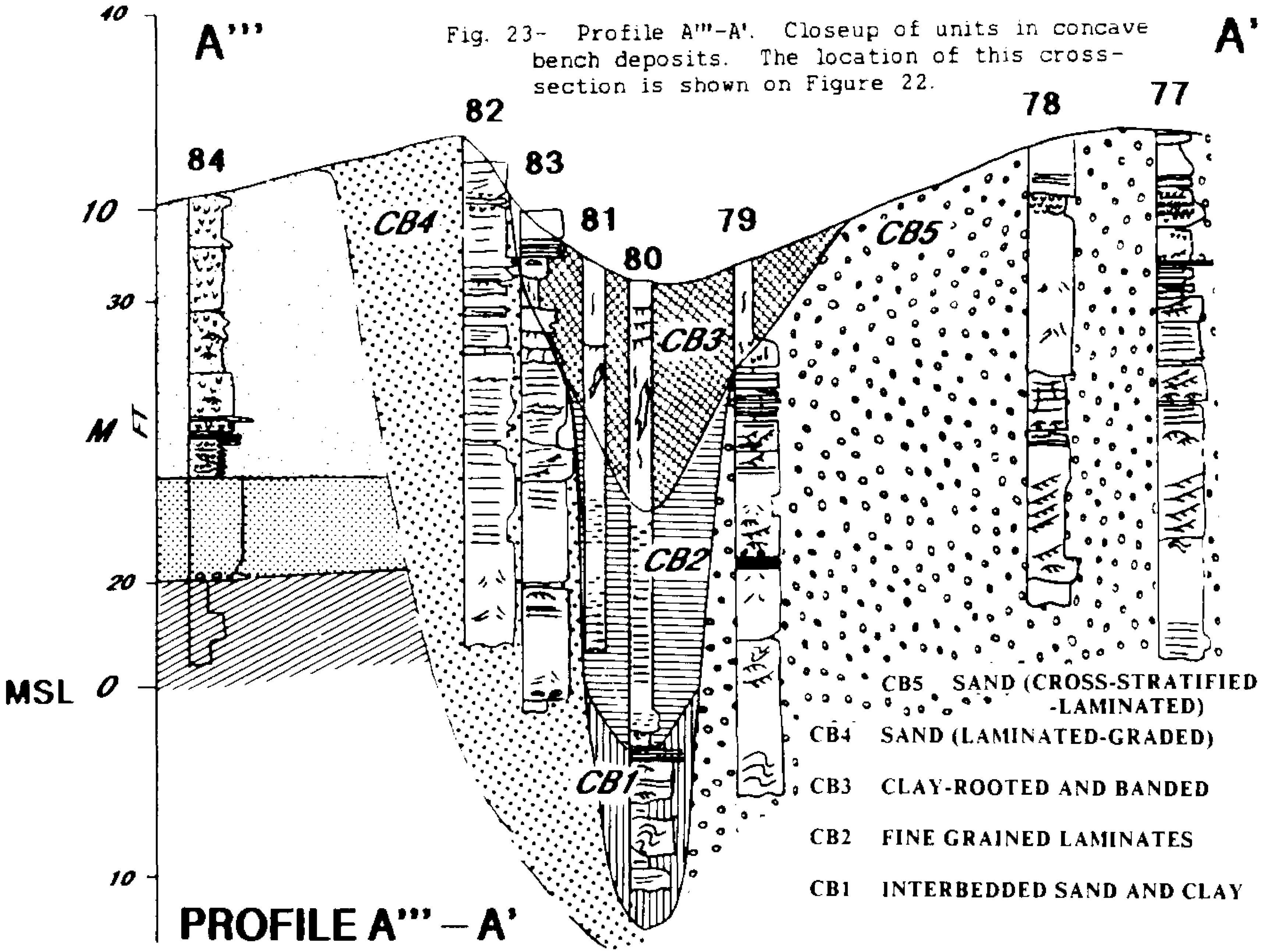


Fig. 23- Profile A'''-A'. Closeup of units in concave bench deposits. The location of this cross-section is shown on Figure 22.

CONCAVE BENCH DEPOSITS: SWALE FILL UNITS

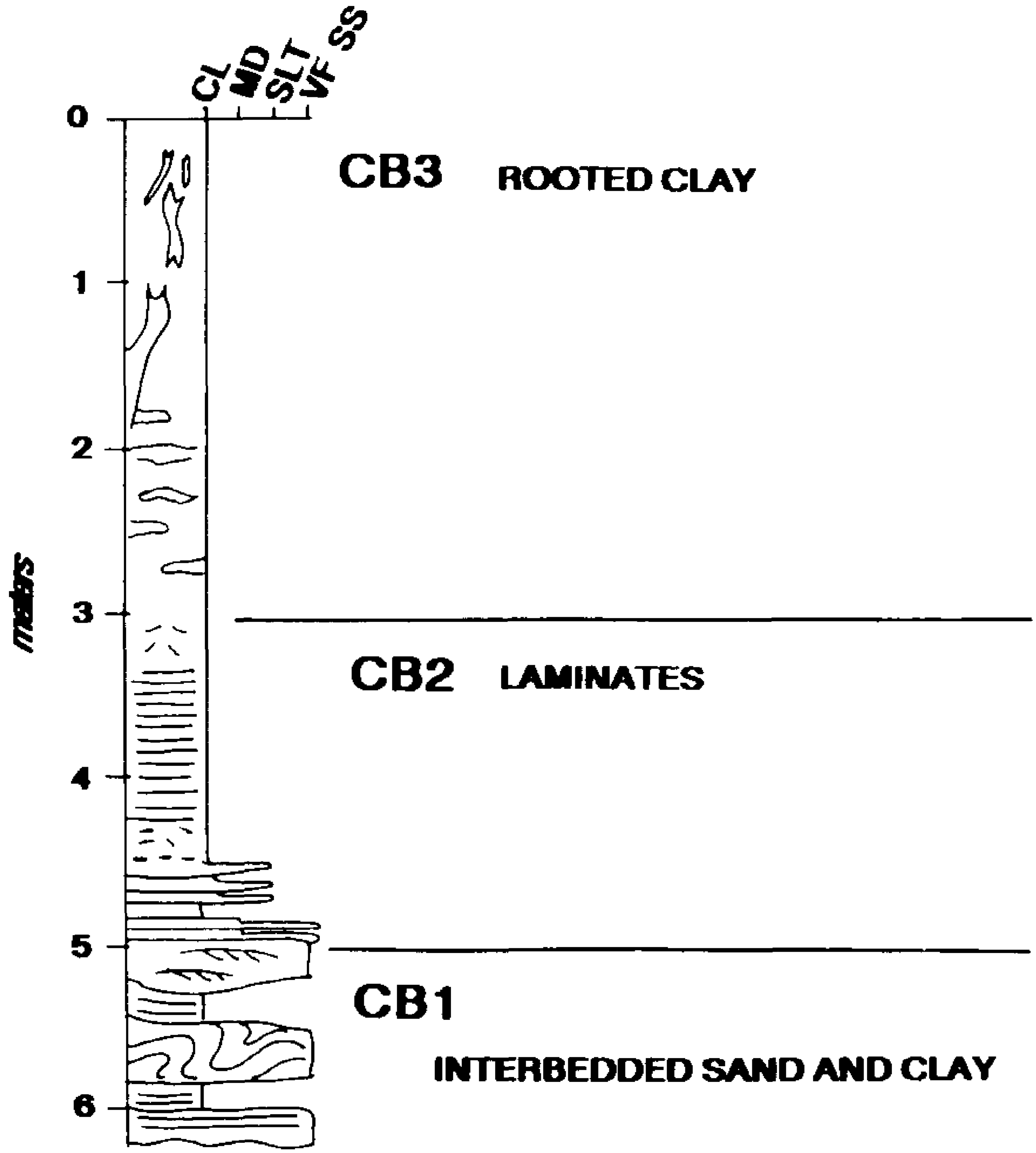


Fig. 24- Stratigraphic section through the swale-fill of a concave bench deposit.

The sand grades in stratification upwards into laminated silt, lenticular bedding and laminated clay respectively. A rooted zone is preserved as root-hairs with iron-oxide coatings at the top of the clay. These clays are sharply overlain by a bed of convoluted sand with abundant organic debris (Fig. 25G, 25H). Above this is a second layer of laminated clay.

The uppermost sand bed is complexly stratified. At its base, it is ripple-drift cross-laminated. The ripple-drift sets grade upward into parallel laminations and then crenulated laminations which are truncated by a scour surface. The scour is filled with small-scale trough cross-laminated sand. The small cross-sets are replaced in succession by ripple-drift, sinusoidal ripples and some slightly convoluted laminations. These current structures are barely discernable in the X-ray radiograph shown in Figure 25F. This sequence is overlain by clay-rich laminates (Fig. 25E, 25F) of Unit CB2.

CB2-- This unit consists of complexly interlaminated clay, silt, very fine sand and leaf debris (Fig. 25C, 25D, 25E, 25F). The transition between the highest sand bed in CB1 and the clay/leaf laminates at the top of CB2 is gradational with respect to stratification and grain size. Graded layers of mud and sand are replaced upsection in succession by laminated silts and clays and then by laminated clay.

Each graded layer consists of a basal 1 mm thick discrete sandy lamination that is overlain by 2-3 cm of silt-rich mud. A mm-thick layer of leaf debris may be present at the top of the mud (Fig. 25E, 25F). Above this are interlaminated clays and silts with sporadic

Fig. 25- Swale Fill Units. (See photograph on next page).

A. CB3: Photograph of rooted clay with Fe-oxide coatings on small root hairs (dark spots). (Core 79).

B. CB3: X-ray radiograph showing structureless clay riddled with small root hairs with Fe-oxide linings (white outlines). (Core 79).

C. CB2: Photograph of fresh core showing apparent lack of structure in laminated clay. (Core 80).

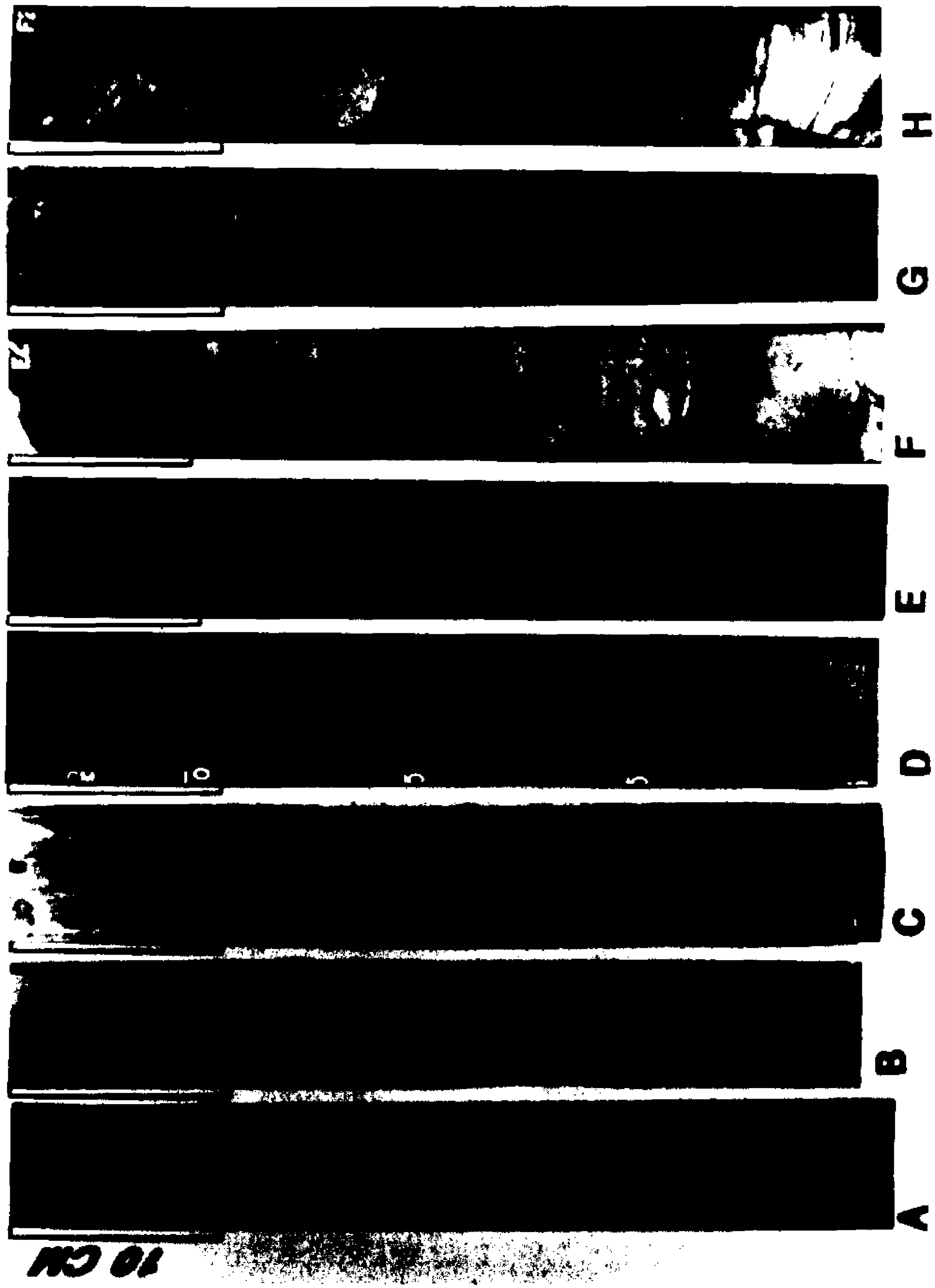
D. CB2: X-ray radiograph of laminated clay with (darker) organic-rich laminae. (Core 80, Depth: 492-532 cm).

E. CB2: Photograph showing laminated clays being replaced in succession downsection by interlaminated silt and clay, and then ripple laminated very fine sand with intervening clay laminations. (Core 80), Depth: 452-492 cm).

F. X-ray radiograph of same core segment shown in E.

G. Complexly interlaminatd very fine sand, silt and mud is disrupted into convoluted bedding. Distortion may be an artifact of coring. Clay-rich sediment is dark in both the photo (G) and the X-ray radiograph (H). The base of the slab consists of undisturbed ripple-laminated sand which is interlaminated with clay and mud. (Core 80).

H. X-ray radiograph of same slab shown in G.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leaf-rich horizons.

The upper part of this unit consists of a thick zone of minutely laminated (0.5-2.0 mm) clay (Fig. 25C, 25D) which becomes increasingly oxidized up-section. Individual laminations alternate in color between gray and yellowish gray with the tone probably being controlled by grain size and organic content. Locally fragments of plant debris which appear as dark rods in X-ray radiographs are present. They appear to be randomly oriented because of disruption due to coring. The organic fragments probably were originally present as clay/leaf laminates.

CB3-- This unit is rooted (Fig. 25A, 25B) and consists of a lower banded red and gray clay and an upper unbanded brownish-gray clay. Large root burrows locally penetrate and disrupt the clay giving it an internally brecciated appearance in X-ray radiographs. It also contains vertical root hairs which have iron-oxide linings.

This unit is similar to the rooted clays of the backswamp (FB4). However, the clays in this unit are smoother (non-cracked) and less compacted than the backswamp clays. They also do not exhibit the pelletal fabric which is common in backswamp clay. Locally this clay has horizons of roots or leaf fronds which are coated with carbonates(?). These irregular horizons are spaced up to several cm apart.

Bench Margin Deposit

CB4-- Unit CB4 lies along the margin of the concave bench between the levee and the swale fill (Fig. 22, 23) and may interfinger with CB1, the basal unit of the swale fill. It is predominantly a laminated fine to very fine sand with interspersed clay-rich horizons that become increasingly more common up-section. The thickest, coarsest-grained sands are present in the lower part of the section (Fig. 26). Sand beds thin and grain size within sand beds decreases up-section.

Stratification in this unit is quite complex. Basically the lowermost sand beds contain graded layers, the intermediate sand beds contain graded laminations, parallel laminations, ripple-drift, and small-scale cross-stratification, and the upper sand beds contain parallel or graded laminations with rooted mud drapes.

Clay is present throughout the section 1) as drapes over ripple forms or the flat tops of sand layers, 2) in complexly interlaminated intervals (laminated clay or interlaminated silt, clay and sand), 3) as rip-up clasts along the base of sands that overlie clay layers, or 4) as rip-up clasts along foreset laminations.

The lowermost sand in the unit sharply overlies laminated clay. It is about 2-3 m thick and consists of dark gray, micaceous, fine to very fine silty sand with large wood fragments concentrated near its base. Particulate fragments of leaf and woody debris are scattered throughout. Stratification is poorly preserved due to water saturation and pressure due to coring. The sediment, where undisturbed, consists of graded layers up to 2 cm thick. Each graded layer has a lower sand-rich part that grades upward into a thin (mm) lamination of finer grained sediment (silt, clay or mud) that locally contains detrital leaf fragments.

In the middle part of the unit the sand becomes tan in color, very fine grained, micaceous and much more variable with respect to stratification. Here graded layers are thinner (less than 1 cm) and

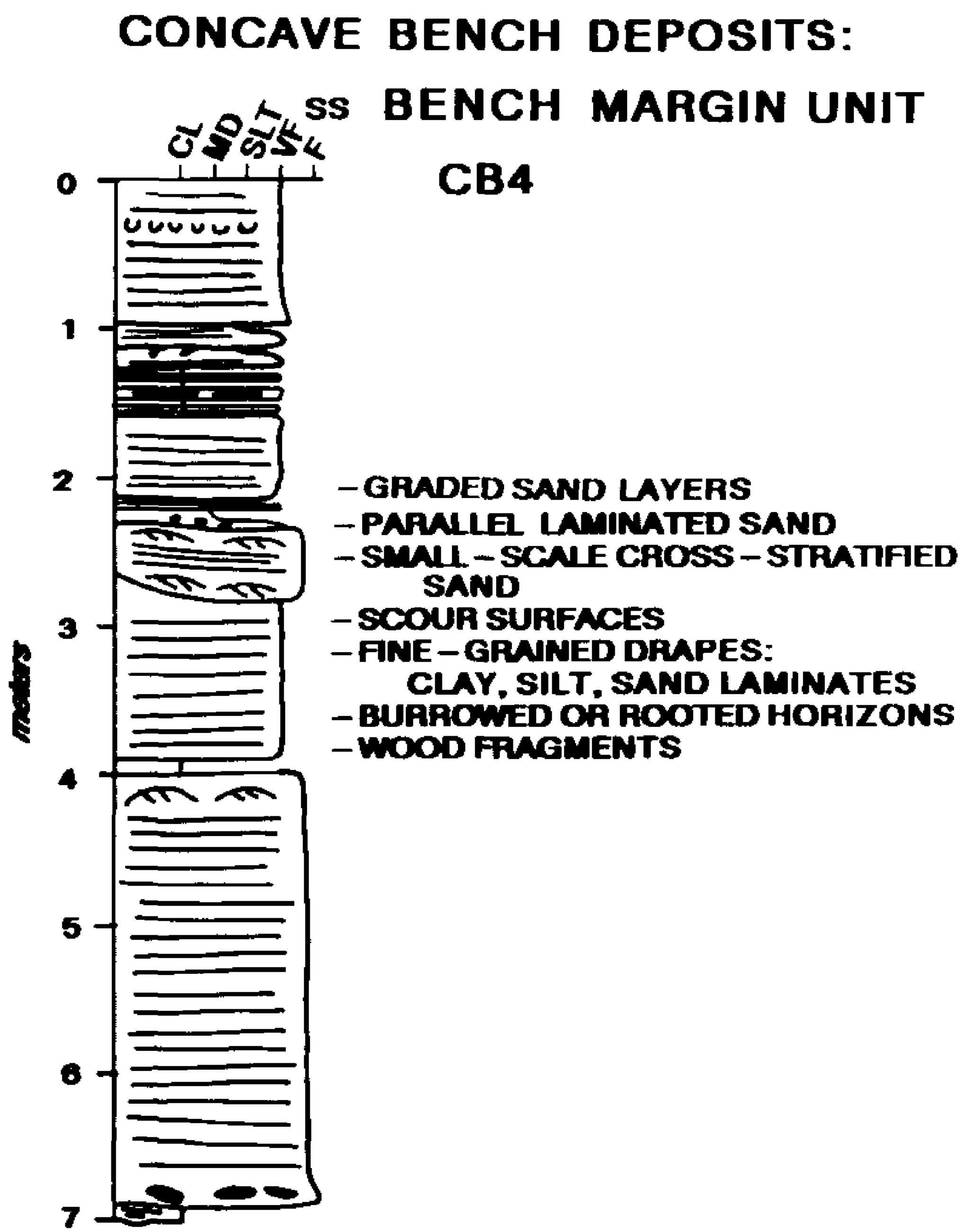


Fig. 26- Composite stratigraphic section through bench margin deposit, unit CB4. (Cores 82, 83).

parallel laminated beds are more common. Ripple drift, ripple laminations and scoured surfaces are also present. Organic debris is rare except where it is concentrated locally on the lee-sides of very low-angle climbing ripples (Fig. 27E). Rootlets with Fe-oxide coatings penetrate the sand beds in the upper 3 m of the cores (Fig. 27A, 27D).

Core 83 exhibits very well-developed cross-stratification which appears to climb (as ripple-drift) for a few cm and several truncation surfaces (Fig. 27E). Tiny backflow ripple laminations are present on the lee side of a climbing ripple form. In Core 82, cross-stratification and ripple-drift is completely absent and graded sandy laminations are the principal stratification features (Fig. 27A, 27B, 27C).

The upper part of this unit consists of more thinly interbedded laminated sand and clay- or mud-rich horizons. Here the sand beds are very fine-grained and well-sorted and are several cm to 30 or 40 cm thick (Fig. 27D). Internally, these sands are either parallel laminated or contain graded layers.

Parallel laminated sands consist of alternating layers of mm-thin, very fine, white sand and finer dark colored opaque mineral silt. These laminations are commonly crenulated and may exhibit tiny flame structures. The thickest parallel laminated layers occur closest to the flood basin contact.

In the upper part of the unit finely laminated sand beds about 10 cm thick grade abruptly upward into a thin silt or mud layer. The top of the fine layer may be burrowed or rooted. These burrowed or rooted horizons become increasingly more common towards the top of the unit

Fig. 27- Photographs of bench margin deposits.

(See photograph on next page).

A. CB4: Graded layers (cm-mm) fine upward from a basal thin (mm) sand seam into silt. Very minute clay or mud drapes may be present at the top of each graded layer. (Core 82, 175-215 cm).

B. CB4: X-ray radiograph of same slab shown in A.

C. CB4: Photo of graded sand laminations and beds. (Core 82).

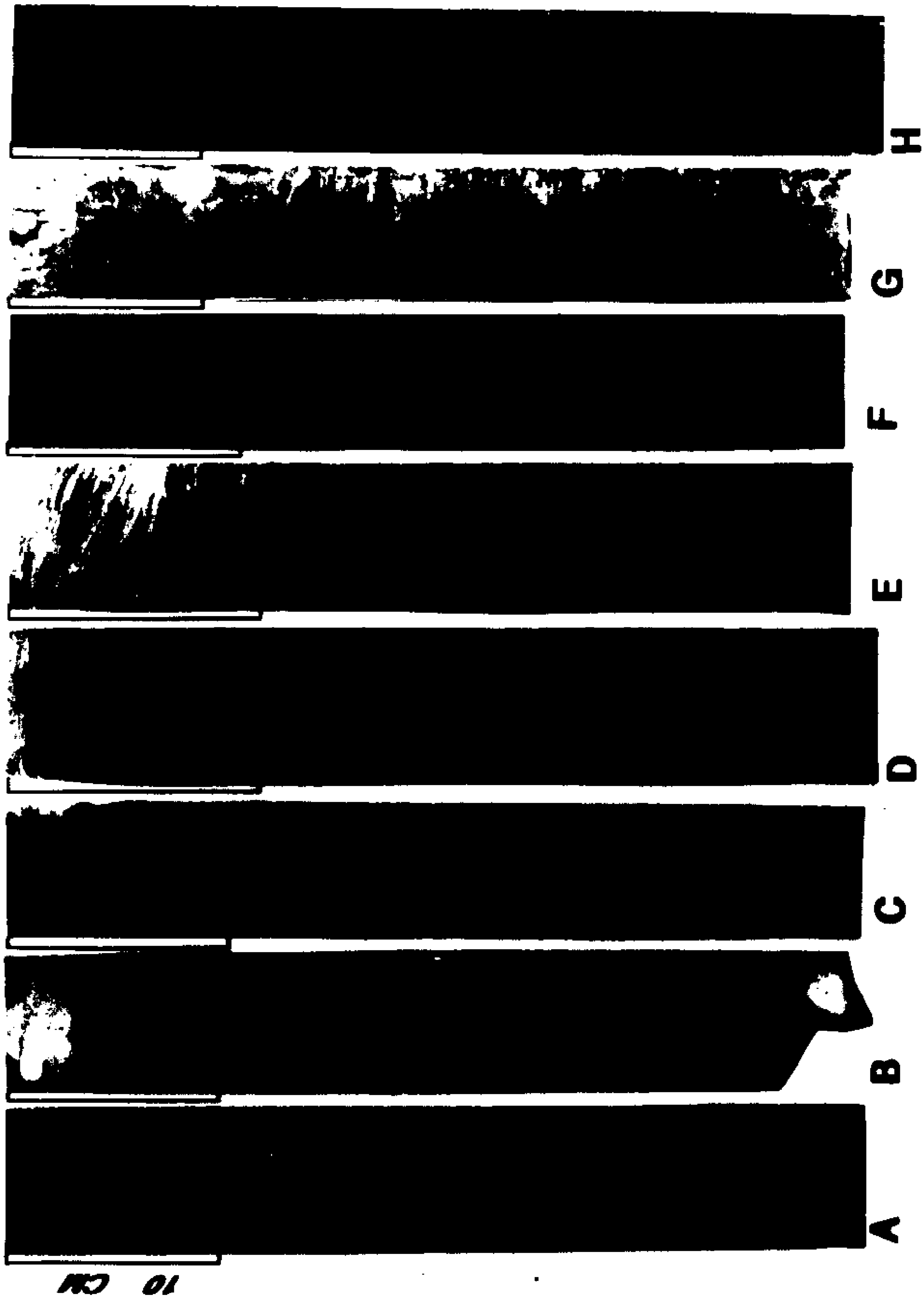
D. CB4: Photograph showing near vertical rootlets with Fe-oxide linings that cross-cut thin sets of parallel laminations or graded laminations and climbing ripples. (Core 83).

E. CB4: Photograph showing thin sets of ripple drift that locally are conformable with sets of parallel laminations. (Core 83, 295-330 cm).

F. CB5: X-ray radiograph showing the typical stratification in CB5: ripple-drift, small-scale cross-laminations and parallel laminations. (Core 77).

G. CB5: Photograph showing thin sets of ripple drift (base), small-scale ripple laminations, and parallel laminations or graded layers at the top. (Core 79).

H. CB5: Clay-rich sediment includes Fe-oxide coatings on root hairs in both massive clay (at base of slab) and clay drapes at the tops of graded layers. (Core 79).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(Fig. 27A, 27B).

Other sand beds contain graded laminations (Fig. 27A, 27B, 27C) that may be arranged in sets. Each graded lamination is thinner than 0.8 cm and fines upward from about 0.4 cm of very fine white sand in the lower part into a browner-colored silt or even a slightly clayey silt. Sets are about 3-10 cm thick with the lower boundaries marked by a coarser-grained graded lamination. The thickness of the graded laminations commonly decreases upsection within the set.

Other graded layers that are common at the top of the unit are quite thick and very muddy (Core 83). These graded layers have a basal discrete sand or silt seam about 1 mm thick which fines abruptly upward into a mud layer which may be as thick as 2 or 3 cm. The top of the mud is marked by a rooted horizon. The roots have Fe-oxide coatings.

Ridge Deposits

CB5-- Unit CB5 underlies the island-like ridge that comprises most of the concave bench (Fig. 22, 23). It predates the swale fill and is probably contemporaneous with Unit CB4.

Unit CB5 is a very fine to fine grained sand with stratification types (Fig. 28) that include ripple-drift cross-stratification, parallel laminations and a variety of small-scale current structures (Fig. 27F, 27G). Soft sediment deformation features such as convoluted bedding and disrupted laminations are also present but these may be an artifact of coring and water escape during core extraction.

All four types of ripple-drift cross-stratification described by Jopling and Walker (1968) are present in the ridge deposit. Organic

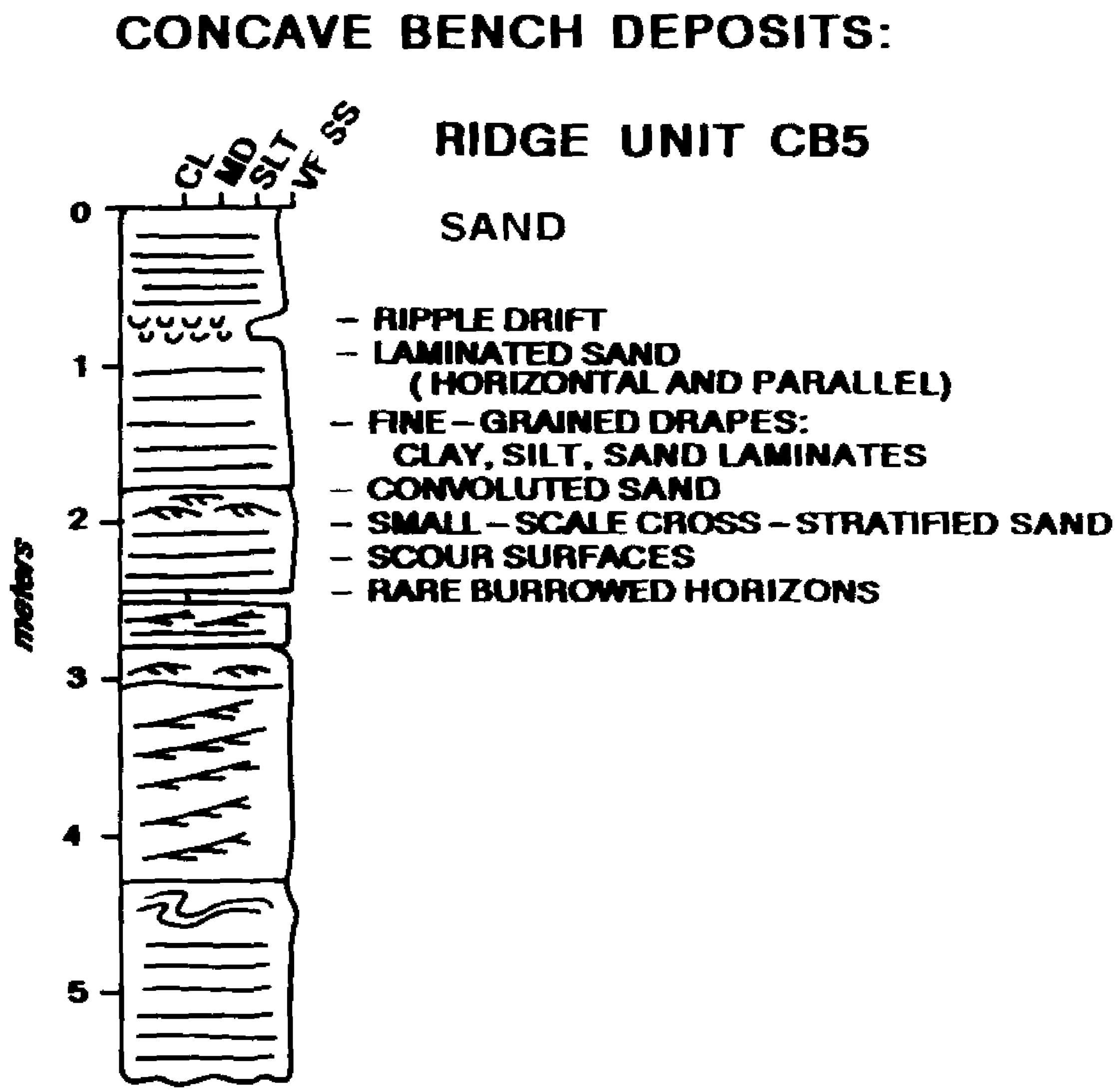


Fig. 28- Composite stratigraphic section through ridge deposit, unit CB5. (Cores 77, 78, 79).

'coffee grounds' are concentrated on the lee sides of ripple forms. Sets of ripple-drift range from 10 to 60 cm in thickness. The thickest sets of single type consist of Type B or A/B transition ripple-drift.

Many sets exhibit an internal gradation in stratification between parallel laminations, sinusoidal ripples, Type B, and Type A ripple drift. This is the 'flood cyclothem' described by Nanson and Page (1983). The sequence then grades up-section into sinusoidal ripples and parallel laminations. In a 60 cm thick set, this sequence of structures was repeated several times without internal discontinuities.

Direction of climb in the ripple-drift cross-stratification is variable. The main river channel is flowing in a southerly direction and most sets climb southward parallel to the long axis of the swale. Other sets, however, appear to climb northward parallel to the long axis of the swale.

All laminated sand and silt beds in the ridge deposits are not gradational with ripple-drift. In the deepest part of the unit, sand beds contain layers up to 1 or 2 cm thick that are normally graded. Other laminated sand beds contain parallel laminations which may be locally crenulated. Laminations consist of thin (mm) white very fine sand laminae separated by dark-colored opaque-rich silty laminae.

Small-scale cross-laminated sets are present in very thin (cm) intervals and commonly grade upward into ripple-drift. Scour surfaces are present beneath the cross-sets. Backflow ripple bedding (Singh, 1972) may be present between successive slip faces. Cross-sets are usually less than 3 cm thick and indicate an apparent flow direction downstream parallel to the long axis of the swale.

Clays are rare in ridge deposits but are locally present between sand beds as thin drapes or in intervals of complexly interlayered fine-grained sediment.

An example of complex interlayering in fine-grained layers separating sand beds is as follows: A sand bed is overlain by lenticular bedding which is replaced upsection by beautiful flaser bedding where clay drapes perfectly outline small isolated ripple forms. The flaser bedding grades upsection into interlaminated silt and very fine sand. Burrows or roots with Fe-oxide coatings terminated upward along bedding planes in the silt.

Interpretation

The concave bench probably originated between 1400 and 1600 A.D. At this time, the high radius of curvature of the meander bend caused it to behave like an abrupt angle turn. As a result the main stream flow impinged on the cutbank side of the channel and eroded out the bench (Fig. 29A). A good portion of the proximal levee deposits at the bench site were removed. Bank cave-ins on the order of 20 to 30 acres in areal extent have been observed to form in a matter of hours along this segment of the meander belt (Carey, 1969). So it is not improbable that this bench formed in a similar manner.

CB5-- Unit CB5 originated as an island-shaped longitudinal bar which developed near the boundary of the flow separation zone (Fig. 29B) at high water in the manner described by Hickin (1978). The morphology of ridge deposits reflects an original bar-like form. The elevation of the island-shaped ridge is about the same as high water levels.

Sediment-laden flood waters flowing in the main channel spilled over into the concave bench, decelerated slightly and deposited sets of ripple-drift as a longitudinal bar. Orientation of cross-strata indicate that the bar accreted mainly in a downstream direction towards the south. The common gradational contacts between parallel laminations and ripple drift types indicate gradual changes in 1) stream power, 2) flow regime, and/or 3) bedload movement relative to fall out of grains from suspension over a single flood cycle (Fig. 17). Ripple-drift indicates lower flow regime conditions. Parallel laminations in association with ripple-drift may represent either upper or lower flow regime conditions. Convoluted layers, if not an artifact of coring, could represent upper flow regime disturbances of pre-existing bedding or could be the result of gravitational sliding of a saturated bed down a slope.

The rarity of fine grained drapes may indicate that 1) velocity of the water did not allow suspension sedimentation to occur, 2) that the bar accreted very rapidly with large thicknesses of sand being deposited during a single flood, or 3) that clays or layers of organic debris that mark the end of flood cycles were eroded away during the next flood.

The configuration of the contour lines on this concave bench indicates that a second more poorly developed bar and accompanying swale also formed within the concave bench.

Once the bar configuration had formed, a swale developed landward from it (Fig. 29B, C). Cross-strata orientation indicates that the mainstream flow could enter the swale from either its upstream or downstream end depending on flood stage, orientation of swale outlets,

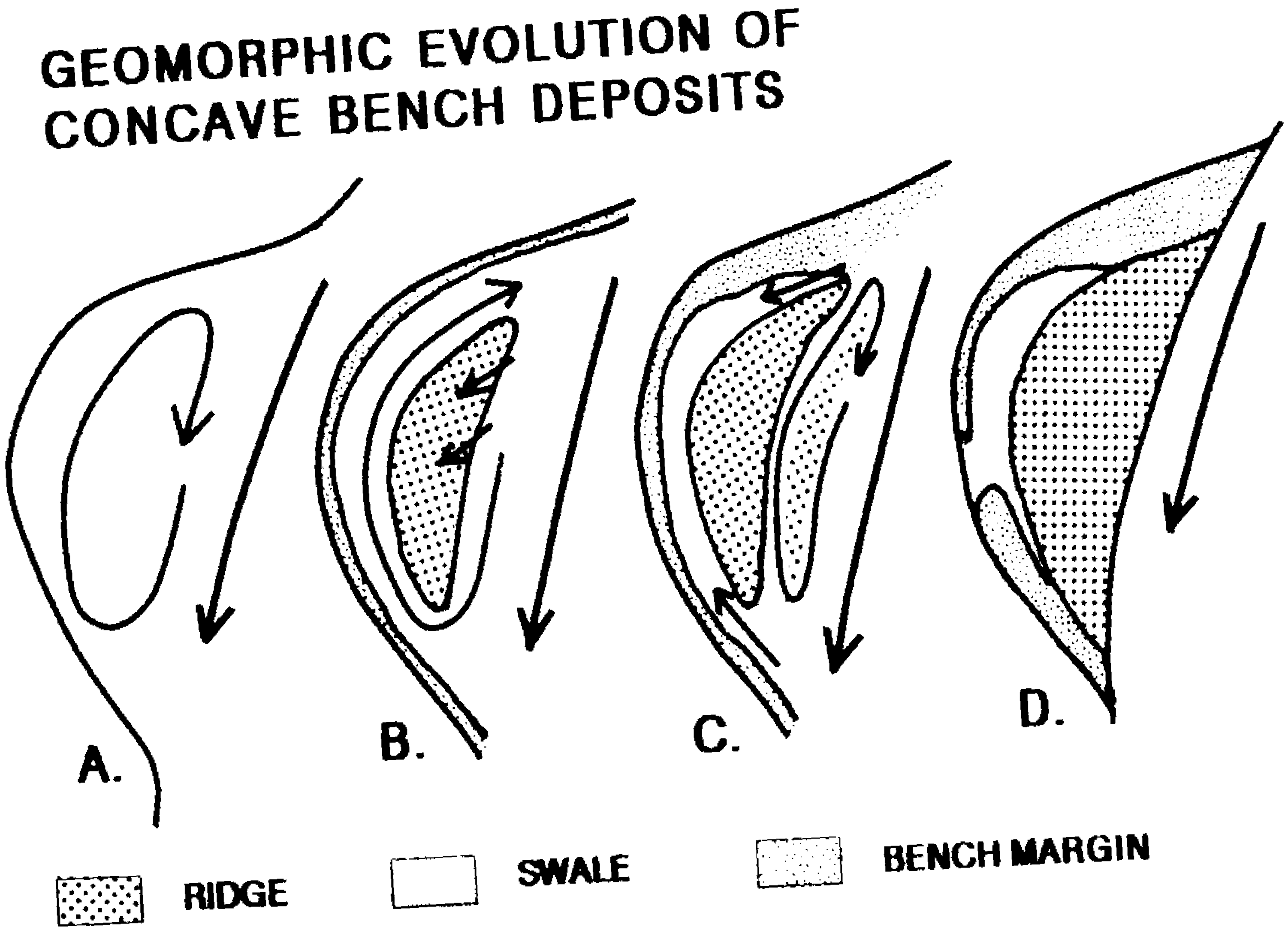


Fig. 29- Evolution of the concave bench deposit.

and the degree of openness of each swale outlet.

The sands with graded layers at the base of the section probably represent suspension sedimentation from multiple turbid sediment-laden clouds entering the swale behind the bar. Most of these basal graded laminations were probably deposited during the same flood season because features such as erosional contacts, clay drapes, rooted horizons and mats of organic debris are absent.

The bar probably migrated landward during its formation because the graded layers are overlain by sets of ripple-drift. Nanson and Page (1983) found that deposition gradually extends the initial bar landward towards the concave bank and that the bar has an abrupt avalanche face along its cutbank side and a gently sloping stoss side that dips towards the channel.

Sand beds with minute parallel laminations may have formed on the landward side of the bar as beach-like deposits in swash zones during falling water levels or may have been deposited from suspension clouds in the manner described by Frostick and Reid (1977).

Small-scale cross-stratification that grades upward into ripple-drift probably represents beginning of flood cycle reworking and deposition. Falling water levels could also generate cross-stratification.

CB4-- As the bar was forming in the flow separation zone, CB4 was being deposited along the concave margin of the bench (Fig. 29B). The slumped bank was reworked and much of the loose material removed. Organic-debris was trapped and deposited here. Eddies carrying suspended fine sand and silt entered the landward side of the bar, decelerated and deposited thick graded sand layers with plant debris as mats on the bench floor.

After this turbid clouds of water carrying finer sediment continued to enter the swale and deposit sets of graded laminations. Currents moved through the swale, ripped up clay layers, scoured surfaces and reworked sand into small-scale cross-stratification. Sediment-laden waters from the main stream locally deposited beds of ripple-drift. Clay layers between sand beds indicate that brief periods of suspension sedimentation from still water separated periods of current activity.

Locally parallel laminated sands were emplaced as either 1) a combination of traction carpet deposition and suspension sedimentation from current pulses in the manner described by Frostick and Reid (1977), or as upper flow regime swash zones as the water level dropped. The crenulations and flame structures along these laminations are caused by either coring or gravity sliding down an inclined slope (beach).

Thinning of sand beds upsection probably is related to a gradual plugging of the open connection with the main stream over time. Burrowed or rooted muds at the top of the unit indicate a shallowing or subaerial conditions and the colonization by plants and/or animals between floods. Thick graded muds with rooted upper boundaries rooted indicate that deep muddy waters periodically incurred into the swale from runoff, a high water table or as spill over from the main stream and then drained away.

CB1-- Eventually, the swale lost its open connection with the main stream flow (Fig. 29D) as the outlets became intermittantly plugged and unplugged. CB1 was deposited during alternating periods of current flow and stagnant water conditions as indicated by the interbedding of sands with current structures and laminated clays.

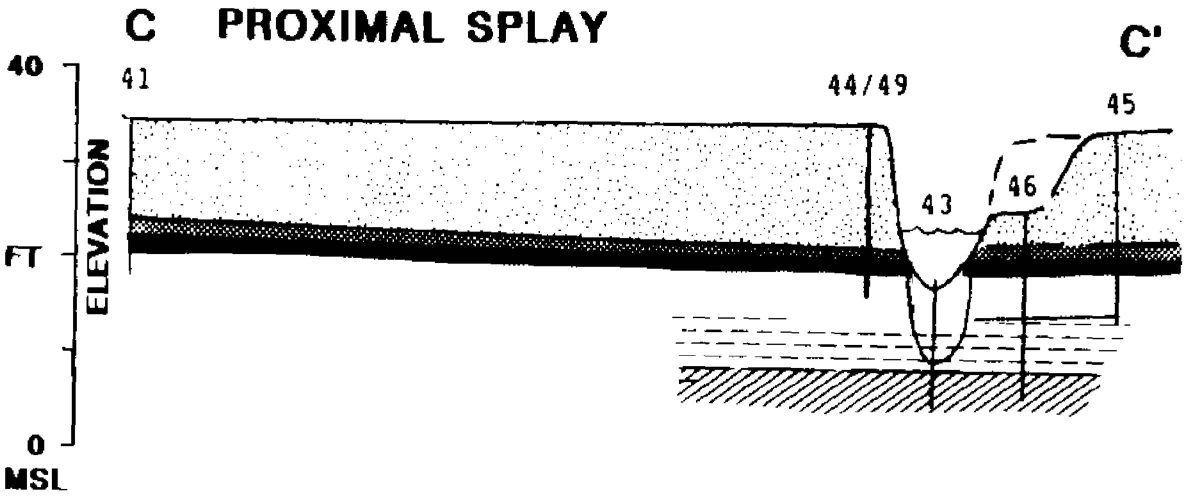
The laminated clays were probably deposited seasonally during prolonged periods of standing water deposition in the swale when the swale-outlets were plugged. The rooted zone at the top a laminated clay bed may indicate very shallow conditions on a stable substrate.

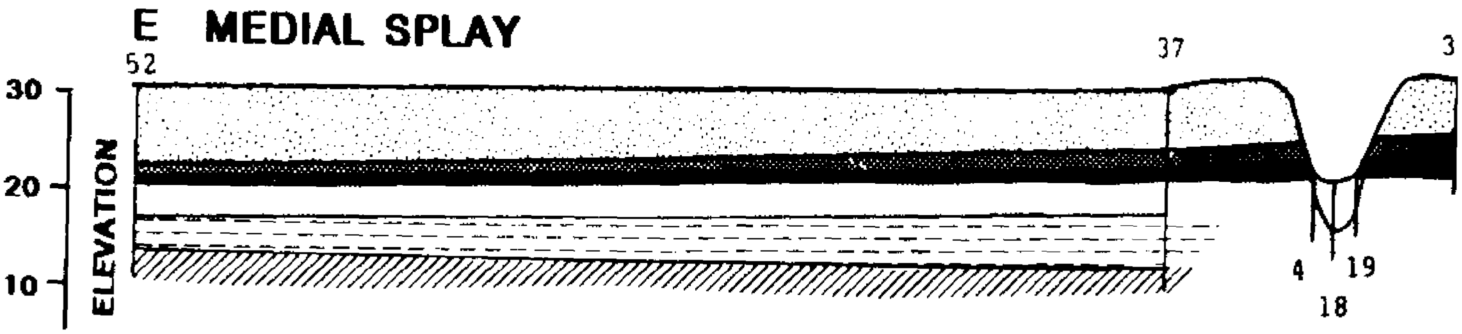
The presence of ripple-drift, small-scale trough cross-stratification, scoured surfaces and parallel laminations in the sand beds indicates that sediment-laden currents moved through the swale intermittently with enough power to scour and rework the swale-floor deposits. Thus the swale-outlets periodically were forced open, probably by flood waters entering from the Mississippi River. Gradations in bedding between ripple laminations, climbing ripples and parallel laminations indicate that the rate of suspended sediment fall-out and possibly flow regime changed over a single swale flooding event. Small-scale cross-stratification is associated with lower flow regimes while parallel laminations could be caused by either upper or lower flow regimes. The presence of a burrowed or rooted zone at the top of a sand bed indicates stable, shallow-subaerial(?) conditions after the water table lowered at the end of a flood.

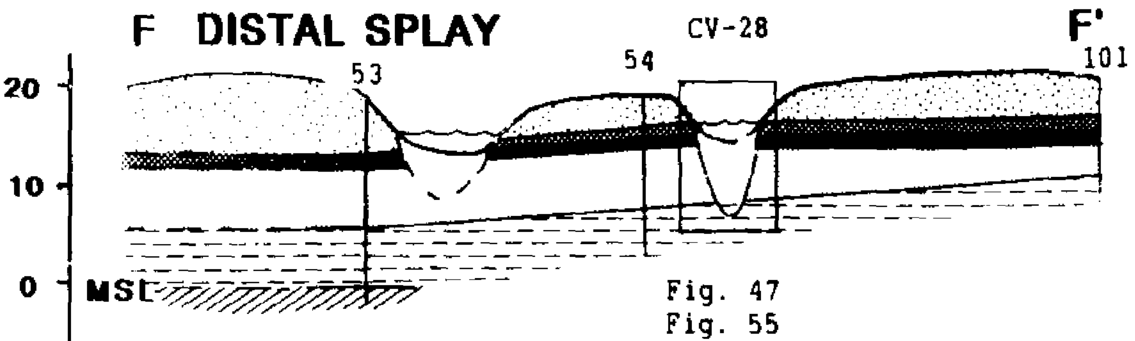
CB2-- The permanent plugging of the swale outlets happened gradually, probably over several years or decades. This interpretation is supported by the gradational change in stratification, the decrease in coarse layer thickness, and the decrease in grain size upsection from sand to clay between units CB1 and CB2.

Each graded layer, sand/clay or silt/clay lamination couplet, or lenticularly bedded silt/clay was deposited from a sporadic pulse of sediment-laden water into the swale. Turbid clouds of water entered the swale during flood stage, decelerated and deposited their sediment load. The coarsest sediment was deposited first with the clays falling out from standing water left in the swale. Leaf layers were probably deposited from suspension near the end of annual depositional cycles. Eventually only clay laminates with leaf layers were deposited seasonally in the stagnant water of the permanently plugged swale as it became completely isolated from the main stream flow. A high water table during flood stage kept the swale filled with ponded water.

CB3-- Gradually the swale floor became sub-aerial as it filled in and plants colonized the swale floor. Clays continued to be deposited during periods of high water table. Laminations are not preserved in the clay because of rooting and bioturbation. Surface mats of leaves that form during dry seasons are preserved as carbonate-coated leaf fronds in massive appearing clays. These leaf layers are the only indication of seasonal deposition.







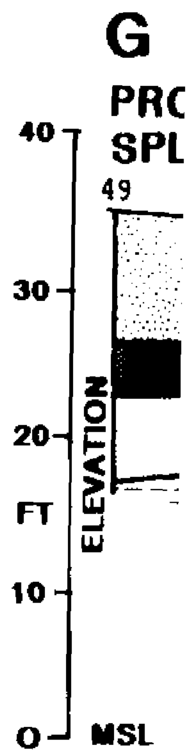
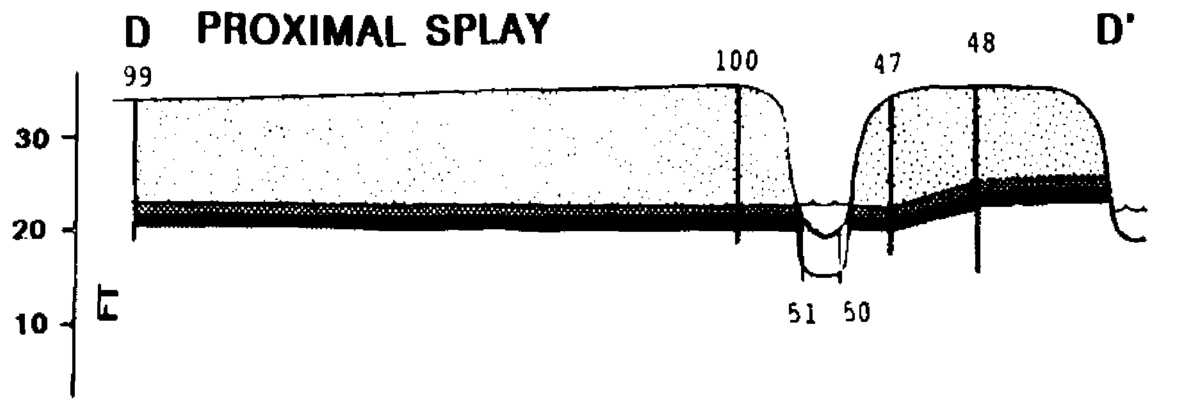


Fig. 30- Cross-sections through splay lobe deposits.
The locations of the profiles are shown in Fig. 31.
(Key on Fig. 22).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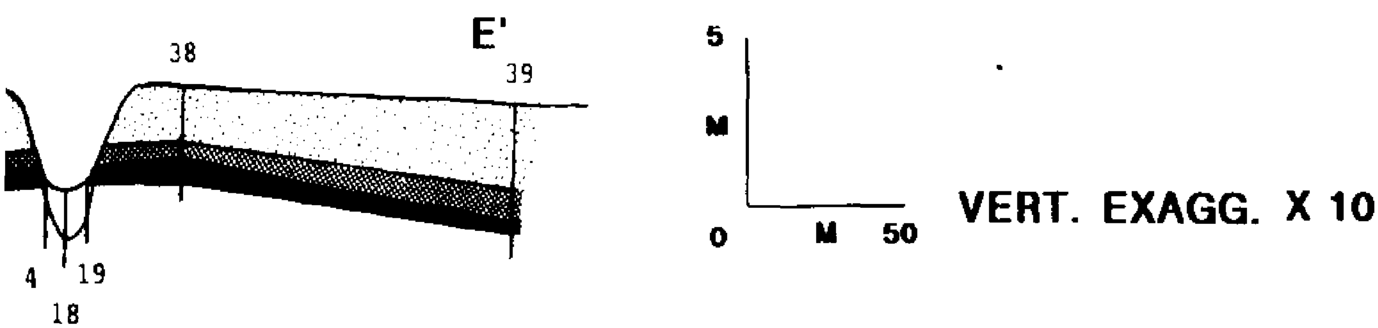
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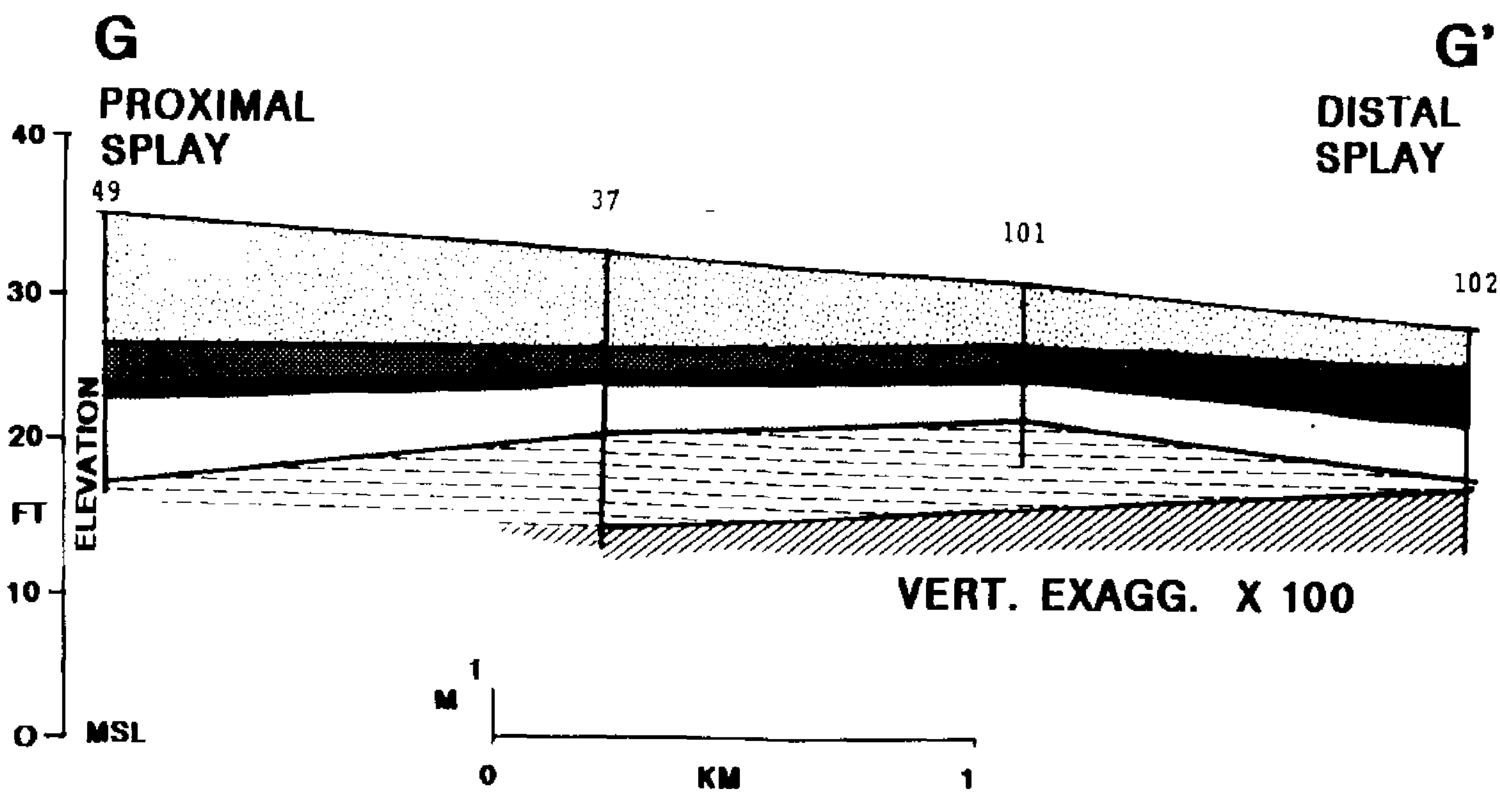
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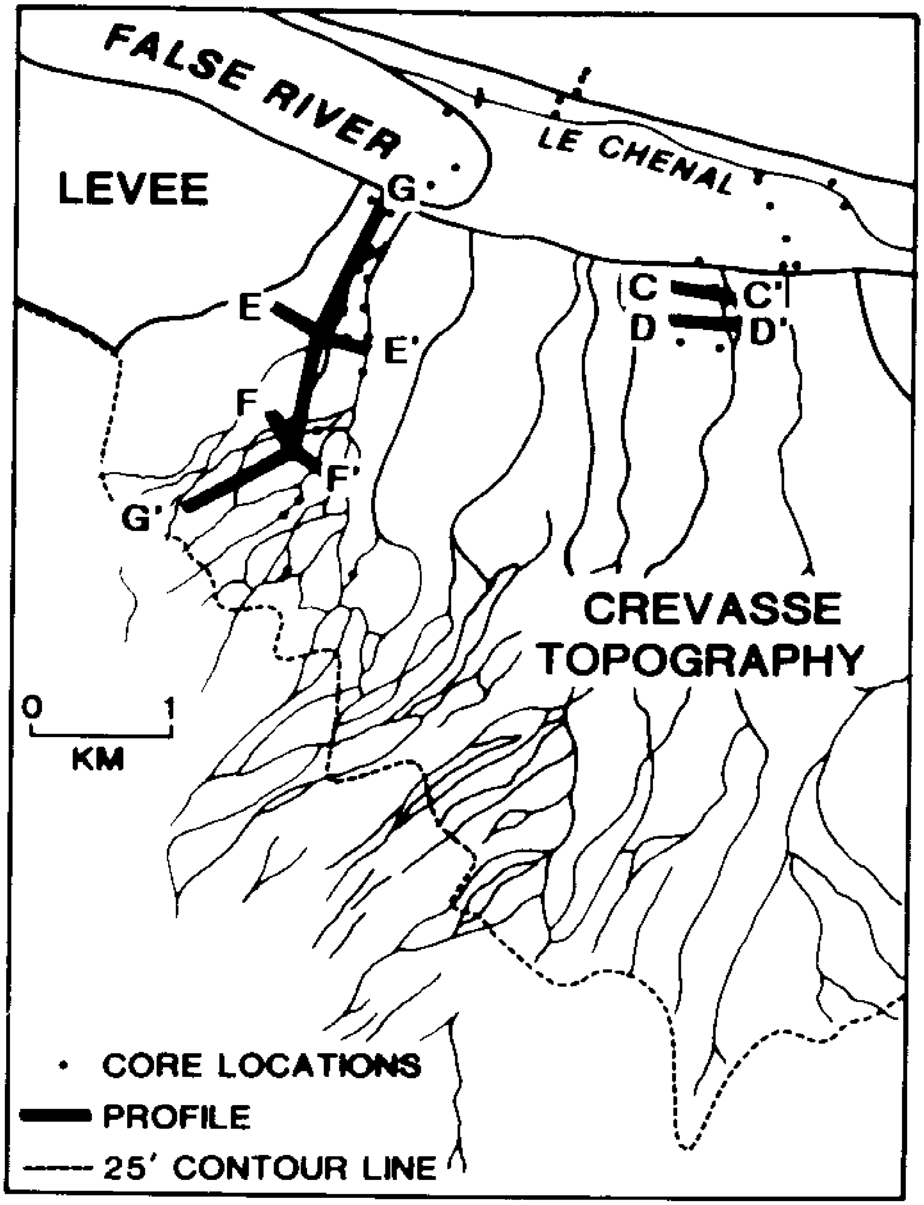


Fig. 31- Locations of splay profiles. The cross-sections shown in Fig. 30.

CHAPTER 5: FLOOD BASIN STRATIGRAPHY

INTRODUCTION

The flood basin deposits, which are divisible into levee, splay lobe, backswamp, and crevasse channel-fill, are separated from the meander belt by a sharp, high-angle contact that is about 10 to 40 M in vertical extent. This contact is present as the relict paleo-cutbank along the oxbow lake and presumably lies in the subsurface on the western side of the concave bench (Fig. 22). These deposits form a wedge of sediment that thins towards the flood basin from the margin of the meander belt. This wedge of sediment has very distinctive sedimentologic features and is divisible into a number of mappable units which are distributed according to depositional environment (Fig. 22, 30, 31).

SEDIMENTOLOGY OF SHEET FLOOD DEPOSITS

Near the meander belt margin, levee, splay lobe and backswamp sediment is mainly deposited from sheet floods originating in the paleo-channel (False River) (Fig. 32A) or in local crevasse channels (Fig. 32B). Distal to the meander belt margin, sediment is also derived from standing or slowly moving water in the flood basin. When a sheet flood overtops the natural banks of a stream, a thin sheet of water flows downslope, towards the flood basin. The sheet of water eventually decelerates to zero velocity because of friction as it flows into an empty flood basin or a flood basin holding standing water.

Deposition from sheet floods results in very distinctive end-member stratification types: 1) rhythmites, and 2) pelletal

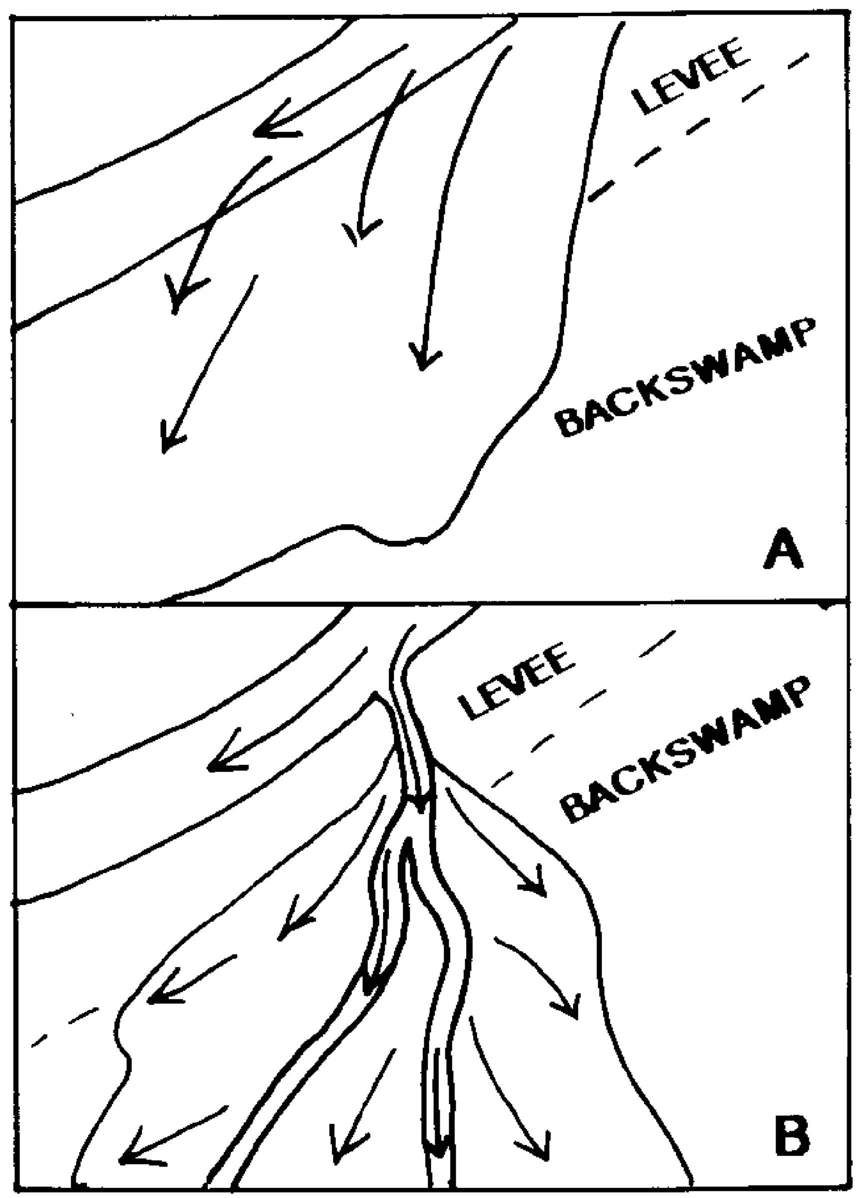


Fig. 22- Sheet floods originating from main channel (A) and crevasse (B) overtopping.

(burrowed) fabrics (Fig. 33). Rhythmites, or rhythmically bedded facies, consist of alternating layers of coarser and finer sediment (Fig. 34) (Reineck and Singh, 1980). A pelletal fabric is defined as sediment which appears to consist of small mm-sized mud-rich pellets surrounded by a better sorted, usually clay free matrix (Fig. 35A, B, C, D). Where rhythmites are extensively burrowed, pelletal fabrics develop (Fig. 36).

Rhythmites

A continuum exists between thick rhythmic bedding (dm), interlaminated lithologies (mm), and graded layers (mm-cm) because all three bedding types result from sheet flood sedimentation. Rhythmites can thus be further differentiated into 1) sandy rhythmites, 2) silty rhythmites, 3) burrowed laminates (thinly layered rhythmites), and 4) graded rhythmites (Fig. 33).

Each rhythmite consists of a coarser layer of silt or very fine to fine-grained sand and a finer layer of muddy sand, clayey silt, mud or clay (Fig. 34). The layers range in thickness from several mm to a maximum of about 20 cm. Each pair of rhythmic beds (coarse and overlying fine-grained layer) can be considered either 1) a fining-upward cycle resulting from decelerating current conditions, or 2) as alternating periods of bedload and suspension load sedimentation. Primary stratification in the rhythmites is typically disturbed by burrowing organisms.

Sandy Rhythmites-- The lower layer in sandy rhythmites (Fig. 37A, B, C) usually includes well-sorted, very fine to fine sand, silt, and silty very fine sand (0.0625-0.125 mm). This coarse layer may initially coarsen-upward and then fine-upward.

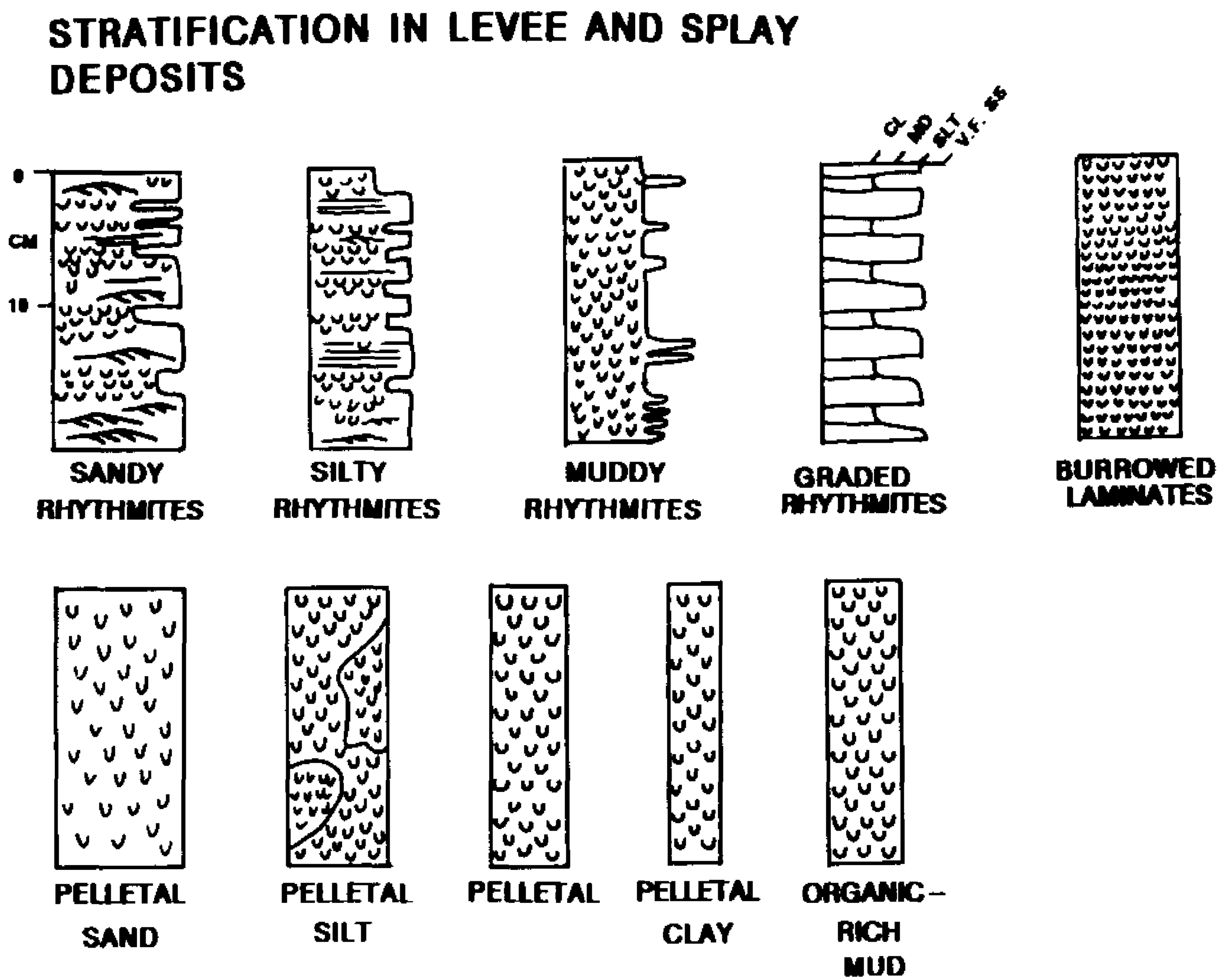


Fig. 33- Stratification types in levee and splay lobe deposits.

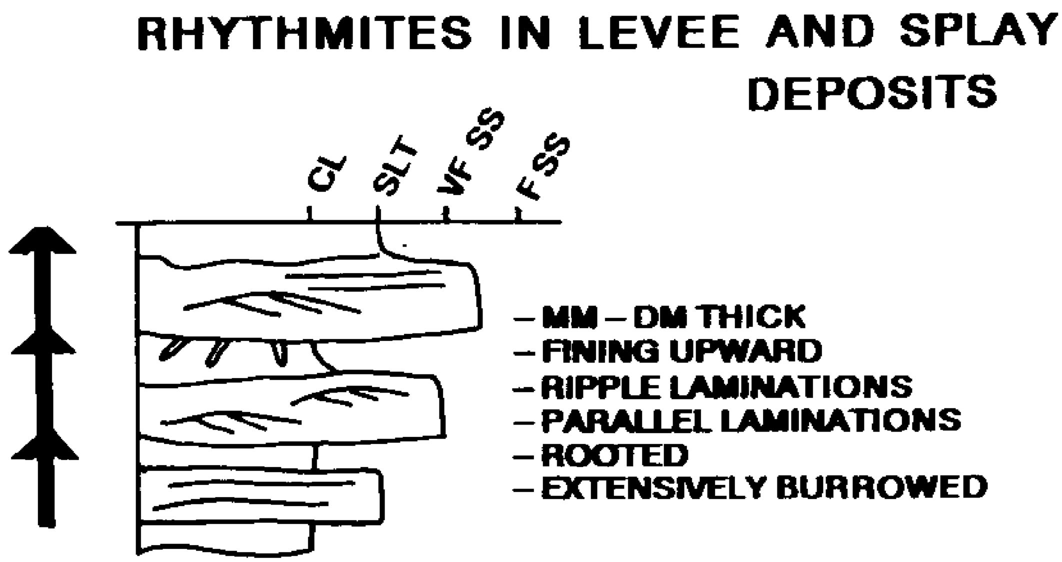


Fig. 34- Rhythmic bedding in levee and splay lobe deposits.

Fig. 35- Flood Basin Units FB7 and FB8.

(See photograph on next page).

A. FB7: Photograph of slab showing pelletal fabric. (Core 10).

B. FB7: X-ray radiograph of same slab in A.

C. FB7: Photograph of slab showing relatively uniform texture of pelletal fabric. (Core 17).

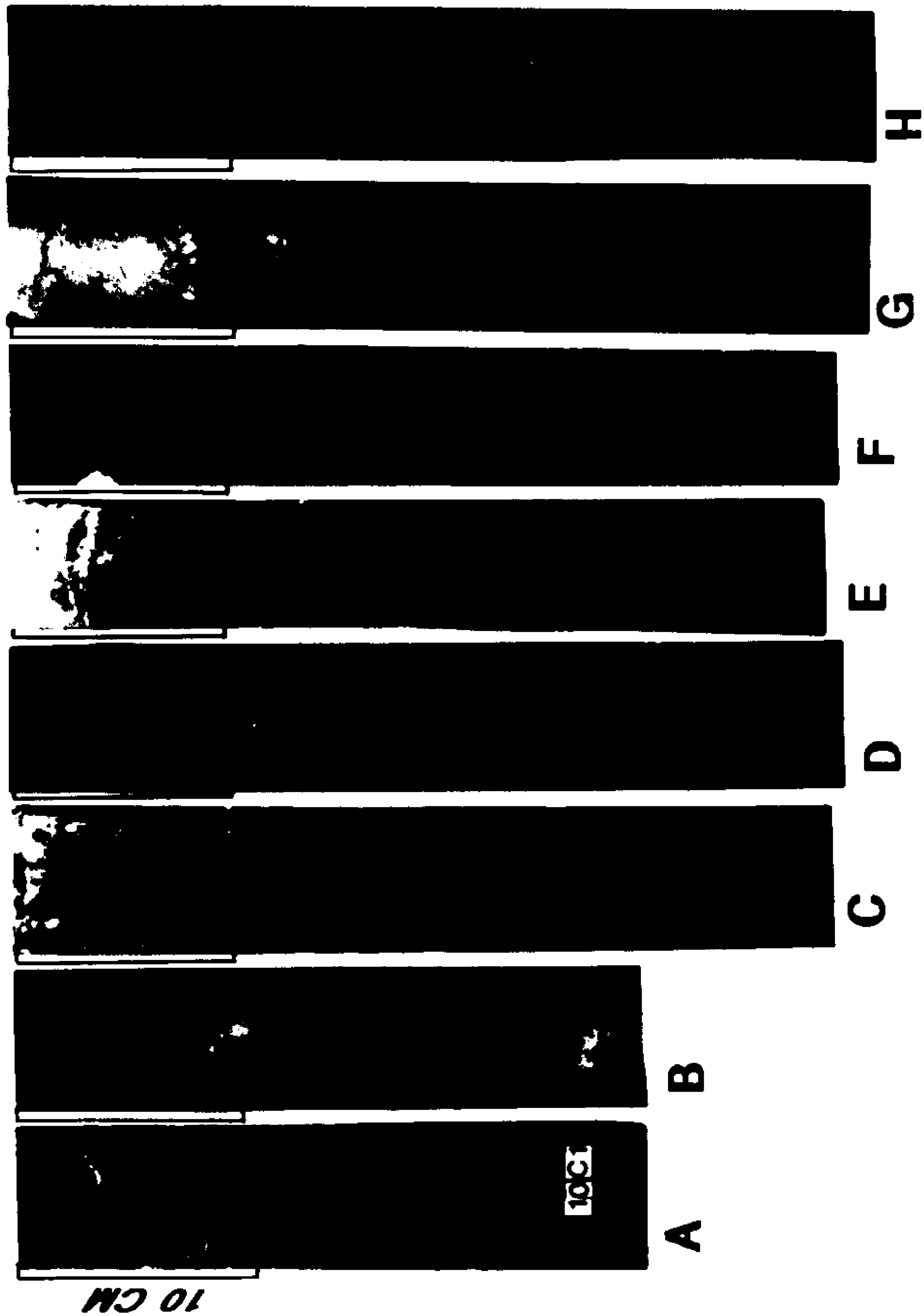
D. FB7: X-ray radiograph of same slab shown in C. Bright spots represent concretionary material.

E. FB8: Photograph showing dark-colored burrowed mud near the base of the slab. It grades upward into a lighter colored, siltier, burrowed, rooted clay (FB4) about 5 cm above the base of the slab. The transition from FB4 into the overlying unit (FB9) is marked by a lithology change from gray clay into light-colored silt. Slab F overlies Slab E for a continuous section of core. (Core 54).

F. FB8: Photograph showing dark-colored, organic-rich mud (FB8) overlying light colored pelletal clayey silt (FB7) along an irregular, but sharply defined contact. (Core 54). Slab F overlies Slab E for a continuous section of core.

G. FB8: X-ray radiograph of the same slab shown in E.

H. FB8: X-ray radiograph of the same slab shown in F.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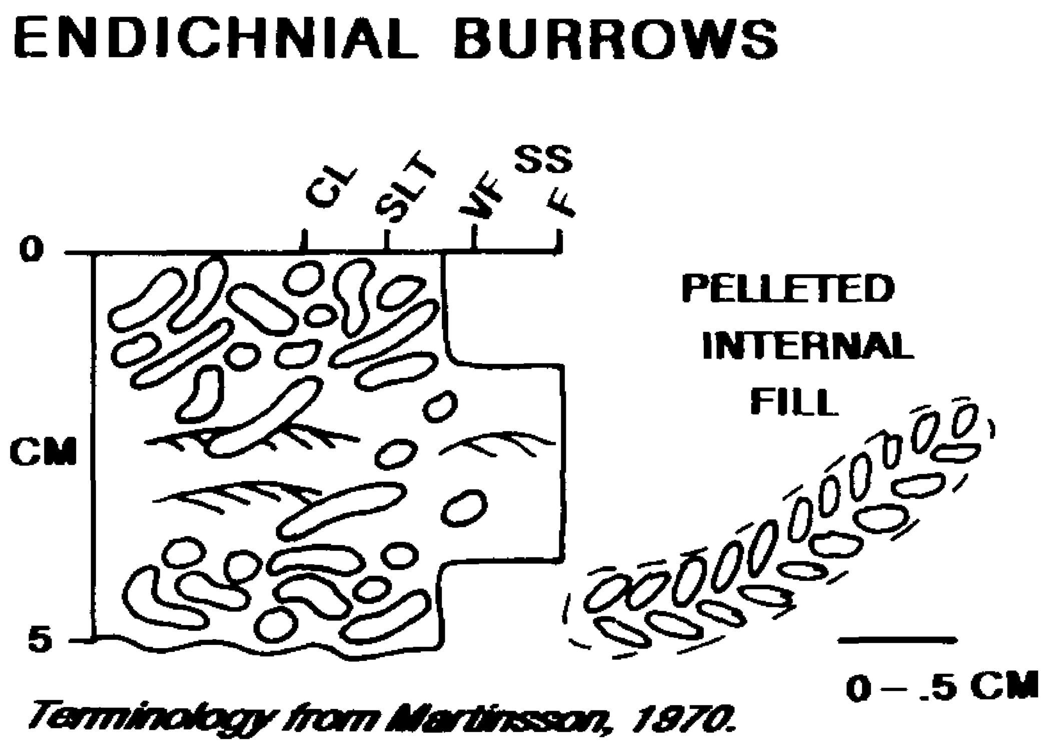


Fig. 36- Relationship between burrows and rhythmic bedding.

Fig. 37- Flood Basin Unit FB9.

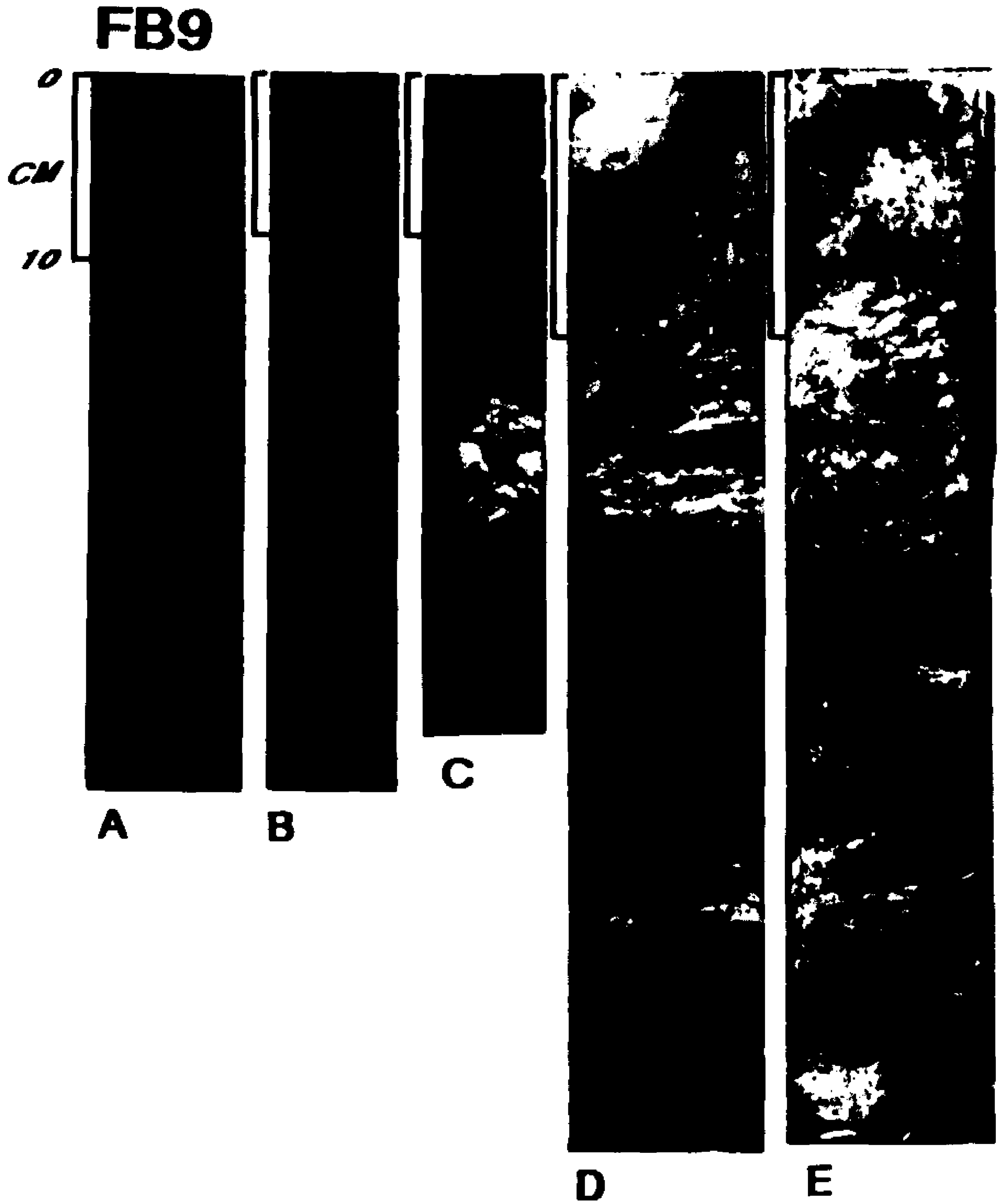
(See photograph on next page).

A. Fine-grained cross-stratified sandy rhythmites cross-cut by large burrow. (Core 86).

B. Well-developed sandy rhythmites with burrowed muds extending into the sand layers. (Core 47).

C. Dark-colored rooted mud (FB4) at the base of the slab is overlain in succession by silty rhythmites, sandy rhythmites and pelletal silt. (Core 49).

D and E. Extensively burrowed silty rhythmites with large patches of pelletal silt and pelletal mud. (Core 75).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Primary stratification consists of traces of very small-scale ripple laminations, parallel laminations and very low-angle cross-stratification. It commonly grades up-section from parallel laminations at the base into ripple laminated coarser sediment and then into finer-grained parallel laminated sediment at the top. Ripple-drift is not present.

Contacts at the base of the coarse layers are either burrowed, erosional, rooted or deformed with flame structures. Burrowed contacts are very common. Endichnial burrows with muddy internal fill extend upward from mud-rich layers into the overlying silt or sand (Fig. 37B). Erosional contacts are flat and overlain by mudball rip-up clasts. Rooted contacts appear as a row of subparallel vertical root hairs, which may be coated with Fe-oxides or carbonate minerals, that extend downward from the contact into mud. Tiny flames of clay-rich sediment may extend upward from a sharp horizontal contact into the overlying sand or silt.

Contacts between coarse layers and overlying fine layers may be gradational, burrowed or sharp. Gradational contacts are rather abrupt and are present as a series of successively finer laminations. Graded contacts are generally disrupted by burrows that extend downward from the finer, muddier sediment. Sharp contacts are present where clay drapes (mm-cm) abruptly overlie the coarser layer in the rhythmite.

Silty Rhythmites-- Silty rhythmites consist of coarse, well-sorted silt layers alternating with clayey silt, clay or mud (Fig. 37D, 37E, 38C, 39B, 39C, 39D, 39E, 39F). Parallel laminations or very small ripple forms are preserved in undisturbed silt layers. A single

Fig. 38- Flood Basin Units FB5 and FB6.

(See photograph on next page).

A. FB5: Photograph of slab showing faint pelletal fabric in the lower part and clay-rich silt above with Fe-oxide concretionary material. (Core 72, Depth: 510-550 cm).

B. FB5: X-ray radiograph of same slab shown in A.

C. FB6: Photograph of slab showing burrowed silty rhythmites. (Core 54).

D. FB6: X-ray radiograph of slab shown in C. Note faint fuzzy white splotches which represent granular Fe-oxides precipitated in the coarser matrix of the pelletal silt fabric.

E. FB6: Burrowed rhythmites and laminates grading upward into pelletal silt (Core 101).

F. FB6: Unburrowed cross-stratified sand being replaced upsection by burrowed sands. (Core 101).

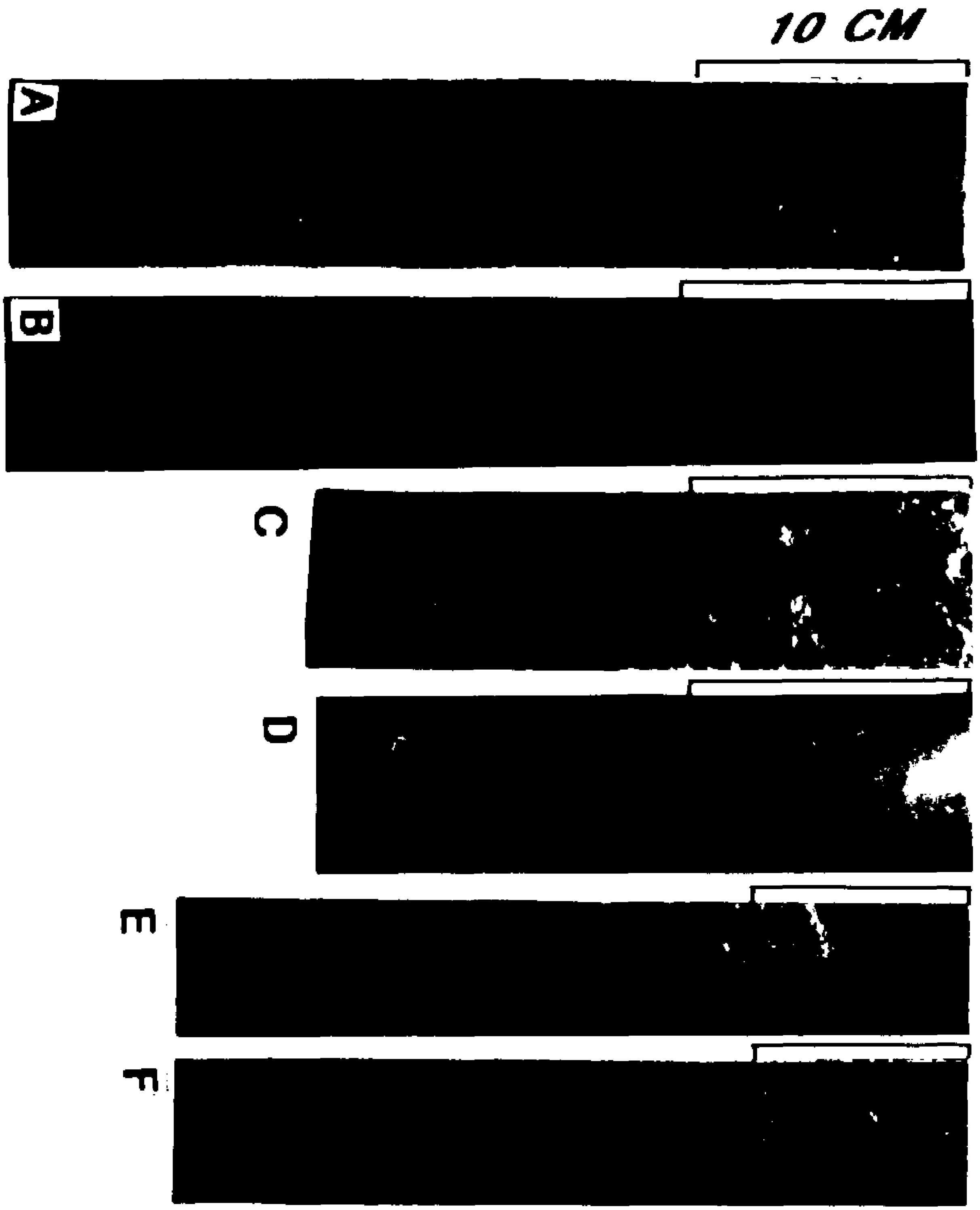
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Fig. 39- Flood Basin Unit FB9. (See photograph on next page).

A. Pelletal very fine sand in surficial splay lobe deposits. (Core 54, depth of about 20-50 cm).

B. Burrowed silty rhythmites with traces of very small-scale cross-laminations at base. In upper part of slab, burrow-fill coalesces to form pelletal silt fabric. (Core 54).

C. Extensively burrowed silty rhythmites with traces of small-scale cross-laminations. (Core 54).

D. Burrowed silty rhythmites cross-cut by large burrows with pelletal infill. (Core 44).

E. Blow-up of D showing details.

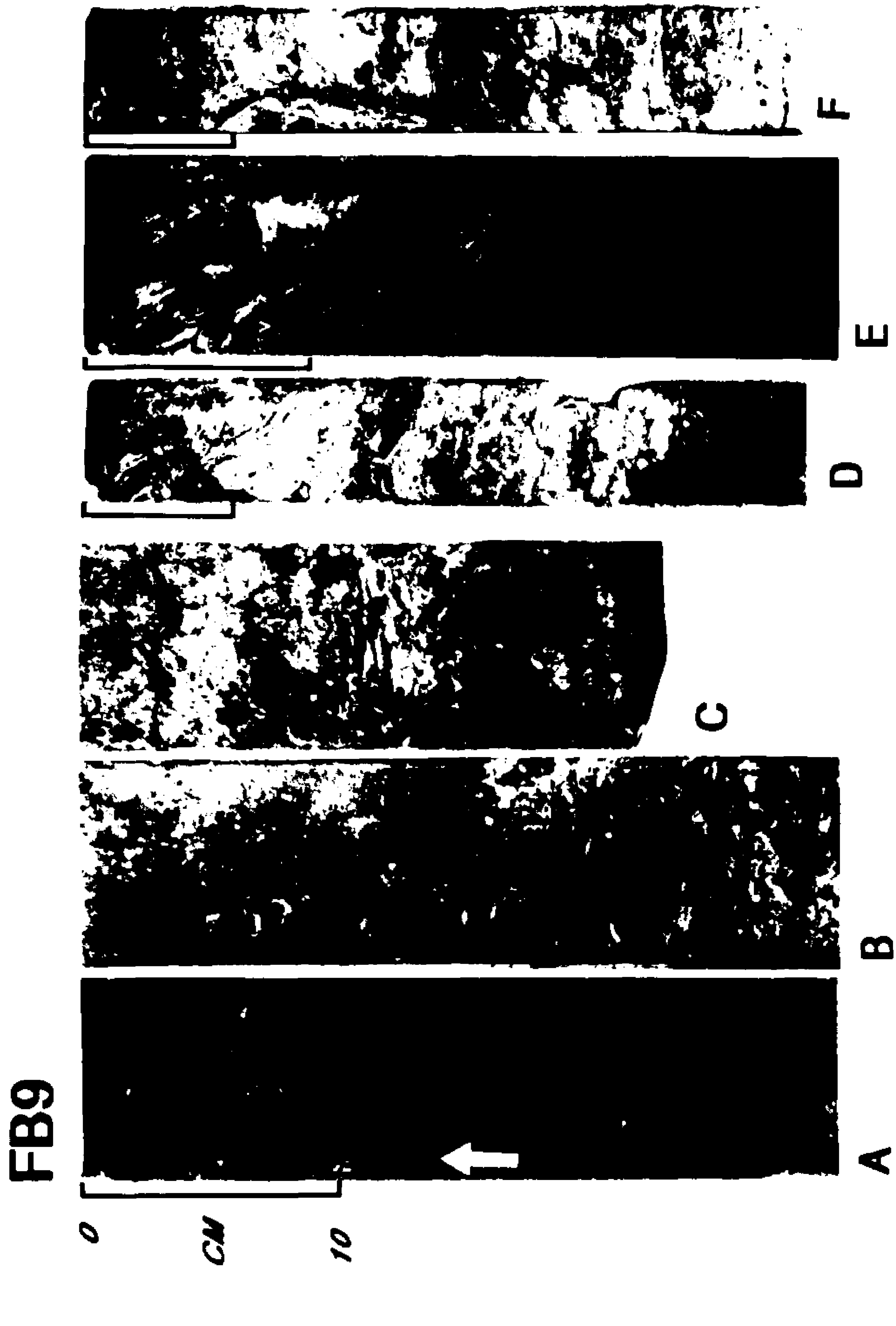
Disrupted very fine sandy laminates with:

a. U-shaped vertical burrows (w);

b. back-filled burrows with spreiten (outlined in black); and

c. large cross-cutting burrows with internal pelletal fabric (v). (Core 44).

F. Silty and sandy rhythmites disrupted by small burrows with pelletal backfill and large root?-burrows. (Core 44).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layer of small ripple forms may be succeeded upsection by parallel laminations and then by the fine layer. Silty rhythmites have the same types of contacts that are present in the sandy rhythmites.

Graded Rhythmites-- Graded rhythmites (Fig. 40A) consist of a lower green clayey silt layer which grades into an upper layer of dark brown organic-rich mud. Scouring may be present along sharp erosional contacts between successive graded beds. These rhythmites have a maximum thickness of 3 cm and they are not burrowed. The mud contains roots which are coated or lined with either carbonates, iron-oxides or pyrite. This type of bedding is rare.

Laminates-- Laminates are present as laminated sand beds and as interlaminated silt and mud.

Laminated sands are typically non-burrowed and very fine-grained. The laminations are thin (mm) and equant, consisting of alternating layers of white very fine sand and black silt-sized opaque minerals. Crenulations in the laminae may be present. The thickest beds are about 40 (?) cm thick.

The interlaminated silt and mud consists of alternating layers of white silt and browner muddier sediment that are 1 to 4 mm thick. These are the thinnest rhythmites identified. The muddy layers have a beaded appearance indicating that they have been extensively burrowed by horizontally moving organisms. The primary stratification is quite well preserved in spite of the burrowed muddy horizons.

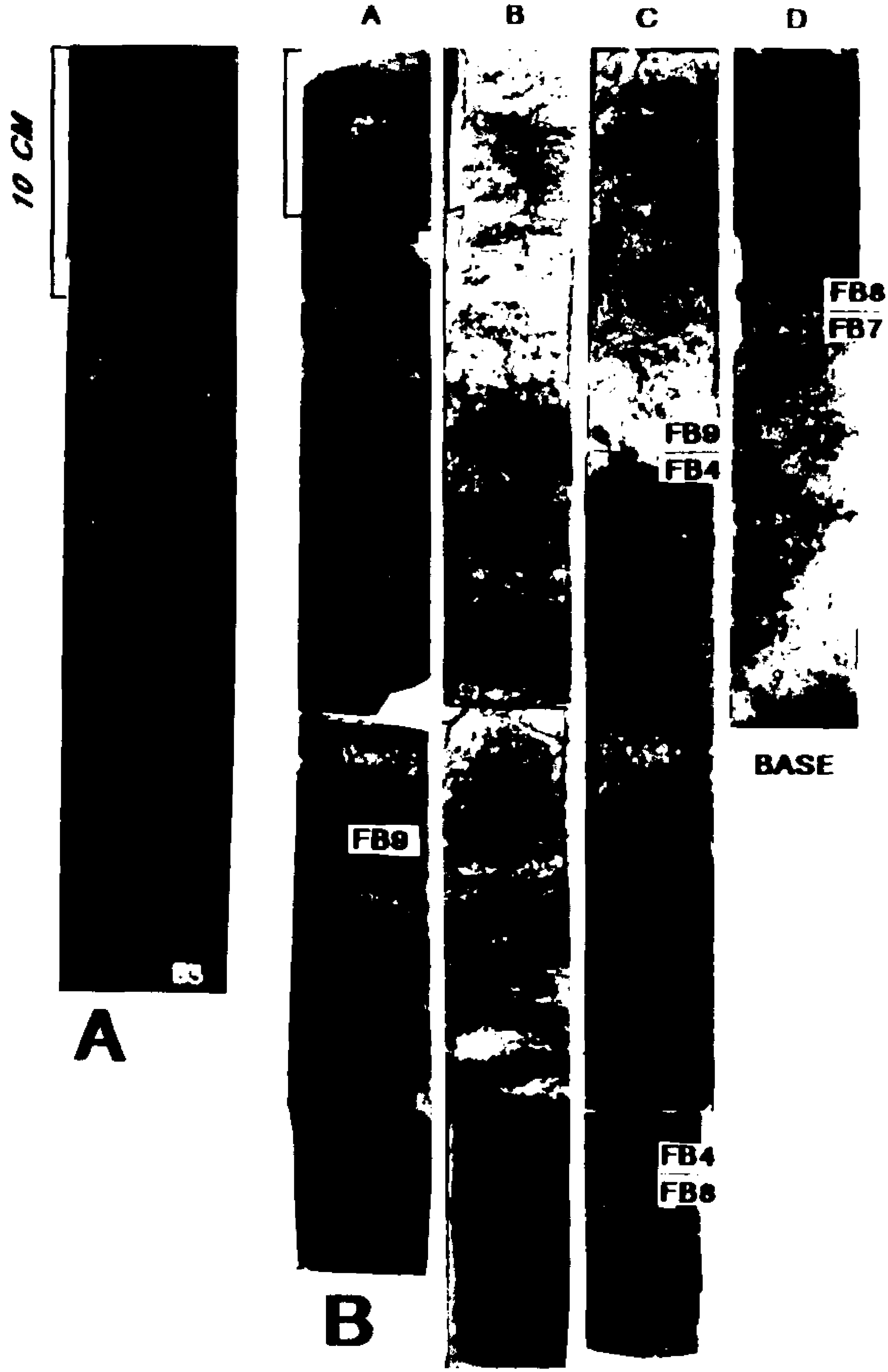
Pelletal Fabric

Primary stratification in rhythmically bedded deposits is usually partially to completely overprinted by burrows with a pelleted internal fabric. The burrows are concentrated in the finer layer of

Fig. 40- (See photograph on next page).

A. X-ray radiograph of graded laminates in FB9 with mineral coatings on leaf fronds and small roots.

B. Sequence of units and bedding types in the natural levee (Core 74, Profile B, Fig. 54). Pelletal silt (FB7) is overlain by organic-rich mud (FB8) which grades upward in the rooted clays of FB4. FB9 overlies FB4 (rooted clay) along a sharp but irregular contact. Here FB9 consists of pelletal silt, burrowed silty rhythmites and burrowed sandy rhythmites. Even the most surficial sediments are quite muddy and extensively burrowed.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individual rhythmites where they form coalescing masses (Fig. 36). They are horizontal to sub-vertical in orientation and cross-cut primary stratification in coarser layers of rhythmites. Pelletal fabric results when burrow density is so great that individual burrow boundaries are lost, primary stratification is destroyed, and all that is visible is a mass of burrow fill (Fig. 35A, C).

The most prominent and pervasive burrow present in these flood basin deposits is an unlined, cylindrical (diameter: 0.7 cm) burrow with a poorly developed meniscate internal structure. Close inspection of the menisci indicate that the burrower sorted the sediment into coarse and fine layers. Discrete mud-rich pellets form finer-grained menisci and relatively loose silt or sand forms the coarser menisci (Fig. 39B). The irregular menisci appear as arcs that do not extend all the way across the burrow (Fig. 39B). Brownish-gray mud-rich pellets appear to 'float' in a coarser, whiter, better-sorted matrix.

Sediments exhibiting pelletal fabrics are further divisible into pelletal sand, pelletal silt, pelletal mud and pelletal clay depending on the dominant grain size present. Pelletal mud and pelletal silt are common lithofacies and are easily recognizable because of the marked contrast between the brown muddy pellets and the white silt matrix. Pelletal clay and pelletal very fine sand beds are more difficult to recognize because of an associated absence of contrasting lithologies.

Pelletal Silt-- Pelletal silt, the most common bedding type in levee and splay lobe deposits, consists of small pockets (mm) of clay, clayey silt or mud in a contrasting matrix of silt, clayey silt or sandy silt (Fig. 35A, B, C). Traces of the original rhythmic layering occur as remnants of clay/silt laminates or thin silty rhythmites (Fig. 39C). Iron-oxides are present as linings around small root traces (mm in diameter) and as diffuse granular precipitants (in X-ray radiographs) in the coarser grained matrix of the pelletal fabric.

Even though some of the more massive-appearing pelletal silt beds resemble resedimented sand-sized rip-up clasts in a silt matrix, I did not interpret them as such because I usually observed a trace of either primary stratification or remnant meniscate structure in them.

Pelletal Sand-- Pelletal sand consists of a very fine-grained sandy matrix that surrounds muddy pellets that are only slightly enriched in clay. This lithology is not very common.

Pelletal Mud and Clay-- Pelletal mud and clay consist of clay-rich coalescing pelleted burrow fill surrounded by a trace of clean silt matrix (Fig. 37D, 37E, 35E). Locally unburrowed remnants of the original bedding are present as angular clasts (?) of minutely (1 mm) laminated white silt and brown clay. Individual burrows in mud or clay are not recognized because the density of the burrows is so high.

The original bedding in pelletal mud or clay probably consisted of: 1) interlaminated silt and clay (minute equant laminations), 2) graded clay laminations, or 3) clayey rhythmites (nonequant laminations where a thin basal silty laminations fines upward into a thicker clay layer). Each clay lamination, pair of laminations or rhythmites would be affiliated with a single flood event.

Origin of Burrowed Fabric

Meniscate burrows similar to the burrows described here have been previously recognized in lower Mississippi Valley levee deposits by

Wells (1977). He was not able to determine what organism was responsible for the burrow but suspected either an arthropod or polycheate worm.

The trace fossil association for non-marine rocks is referred to as the *Scoyenia* ichnofacies (Seilacher, 1967). This ichnofacies includes a number of ichnogenera with meniscate burrows including *Scoyenia* and *Anchorichnus*. These inchnogenera are described by Frey et al (1984) in an attempt to clarify taxonomic and other features of this ichnofacies. *Scoyenia gracilis* has longitudinally striated burrow walls. *Anchorichnus anchorichnus* has a distinctive wall lining. *Anchorichnus coronus* has a thick lining with very prominent menisci. Frey et all (1984) interpret the meniscate burrow that Wells (1977) observed in Mississippi Valley flood plain deposits as belonging to the ichnogenus *Anchorichnus coronus*. However, the common burrow that I have observed do not have either wall linings or prominent menisci. These burrows with their pelleted internal fill resemble the trace fossil, *Muensteria sp.*, as described and photographed by Bracken and Picard (1984, see Fig. 9).

Muensteria is an actively filled, cylindrically shaped, unbranched burrow characterized by a poorly developed meniscate structure and a lack of wall structure and ornamentation. *Muensteria* occurs in both marine (Pemberton and Frey, 1983; 1984) and fully terrestrial rocks interpreted as glacial lake(see Ekdale et al, 1984) and fluvial (Bracken and Picard, 1984; Squires and Advocate, 1984) in origin.

With the exception of the wall lining *Muensteria sp.* is quite similar to *Anchorichnus coronus*. Frey et al (1984) suggest that the prominent internal meniscate structures of *Anchorichnus coronus* were caused by an infaunal deposit feeder that packed or backfilled its burrow as it periodically inched its way forward (i.e. polychaetes and crustaceans). They also postulate three possible mechanisms for the origin of the sorted burrow fill: 1) sediment ingestion and sorting in the animal's gut, 2) sediment sorting by the animal's appendages and body movements as the tracemaker passed materials around itself, or 3) a combination of these two processes (Frey et al, 1984).

Chamberlain (1975) summarized the tracemakers and traces that occur in non-marine environments. He presented several examples of arthropod traces but none resembled *Muensteria*. Several arthropod groups excavate shallow tunnels in wet substrates near streams and pelletize the overlying ceiling sediment as they go. Ceilings probably collapse into the hole shortly after the burrower passes. There is no evidence of tunnel preservation in these cores if this is how pelletization occurs.

The identity of the selective deposit feeder(s) responsible for *Muensteria* and *Muensteria*-like traces is unknown. Aquatic oligochaetes (Squires and Advocate, 1984), polychaetes (Frey et al, 1984; Wells, 1977) and arthropods (Frey et al, 1984, Wells, 1977) have been suggested. I believe this trace is caused by arthropod activity based on the arguments presented by Frey et al (1984).

Interpretation of Stratification

Factors Controlling Stratification-- As water levels rose in the paleo-channel during flood stage, flowing water entered the crevasses as soon as the water elevation exceeded the elevation of the floor of the crevasse. The crevasses then acted as conduits between the paleo-channel and the flood basin, and contributed to the filling of the flood basin. Shallow coalescing sheet flows which were predomiantly subaerial spread out over the splay lobes and levee whenever flood stage exceeded the elevation of the crevasse and main channel levees. Unchannelized sheet flows also formed in distal parts of the splay where crevasses became shallower and narrower. Bank overtopping flows would initially enter topographic lows in the cutbank and in crevasse levees. Depending on duration and magnitude of flooding, subaqueous conditions may have persisted over the whole flood plain allowing sheet floods to enter a standing body of water.

The relative thickness and grain size of the interlayered lithologies in flood basin deposits is highly variable locally. This variation reflects the relative amount of bedload versus suspension load sedimentation, the length of time between successive episodes of bedload transport, local topography, proximity to the source of sediment, duration of sub-aqueous conditions, and the number of overtopping events per annual flood cycle.

The post-depositional modification of primary fabric by burrowers into pelletal fabric is related to thickness of the layers deposited during an annual flood cycle, the number of sheet floods per cycle, the length of time that the layers remain in subaqueous conditions, surface elevation, and the length of time between successive floods.

Proximality Trends-- A great many factors interact to form locally variable stratification in levee, splay and backswamp deposits. However, the distance from the sheet flood source is the principal factor that controls the relationship between layer thickness, stratification type and the degree of bioturbation in these deposits. Such systematic changes in event stratification relative to distance from the sediment source are referred to as 'proximality trends' (Aigner and Reineck, 1982).

Proximality trends are present in levee, splay and backswamp deposits because as the distance from the paleo-channel and crevasses increases, stratification and grain size change in a predictable manner: 1) grain size decreases from fine grained sand to clay, 2) sandy rhythmites are replaced in succession by silty rhythmites, pelletal silt, pelletal mud and pelletal clay (Fig. 41), 3) the thickness of the rhythmic beds decreases, and 4) the intensity of disruption by burrowers increases. A summary sketch shows the surficial distribution of bedding types in flood basin deposits (unit FB9) relative to crevasses and the paleo-channel (False River) which act as sheet flood sources (Fig. 42).

The Effect of Flow Regime-- The sheet flood currents are strongest near their sources because they have a component of velocity from the main stream or crevasse flow as well as a component of velocity from spill-over and acceleration downslope due to gravity. Thick intervals (dm) of parallel laminated very fine sand in the levee cutbank may indicate upper flow regime plane bed conditions. But such beds are rare and restricted to only a narrow zone within meters of the paleo-cutbank.

Well-stratified sandy rhythmites with the thickest sand layers and the least disturbance of primary stratification by burrowers are very common in topographically high areas such as levees along the paleo-channel and crevasses. Here the coarsest sediment (0.25 mm diameter) is rapidly deposited from the sheet flows along the mainstream and crevasse levees. Very fine sand (0.0625-0.125 mm) and coarse silt are

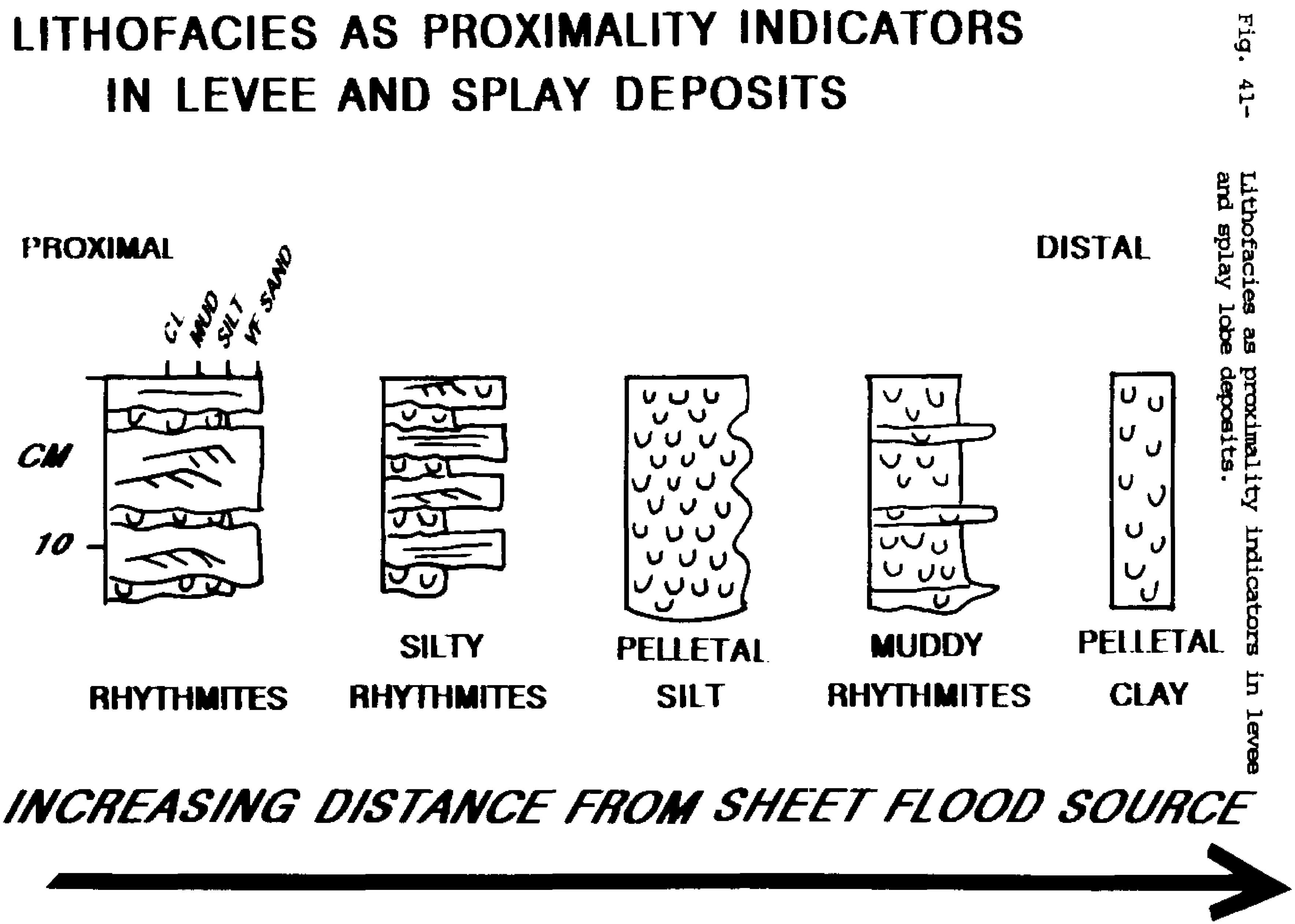


Fig. 41- Lithofacies as proximality indicators in levee and splay lobe deposits.

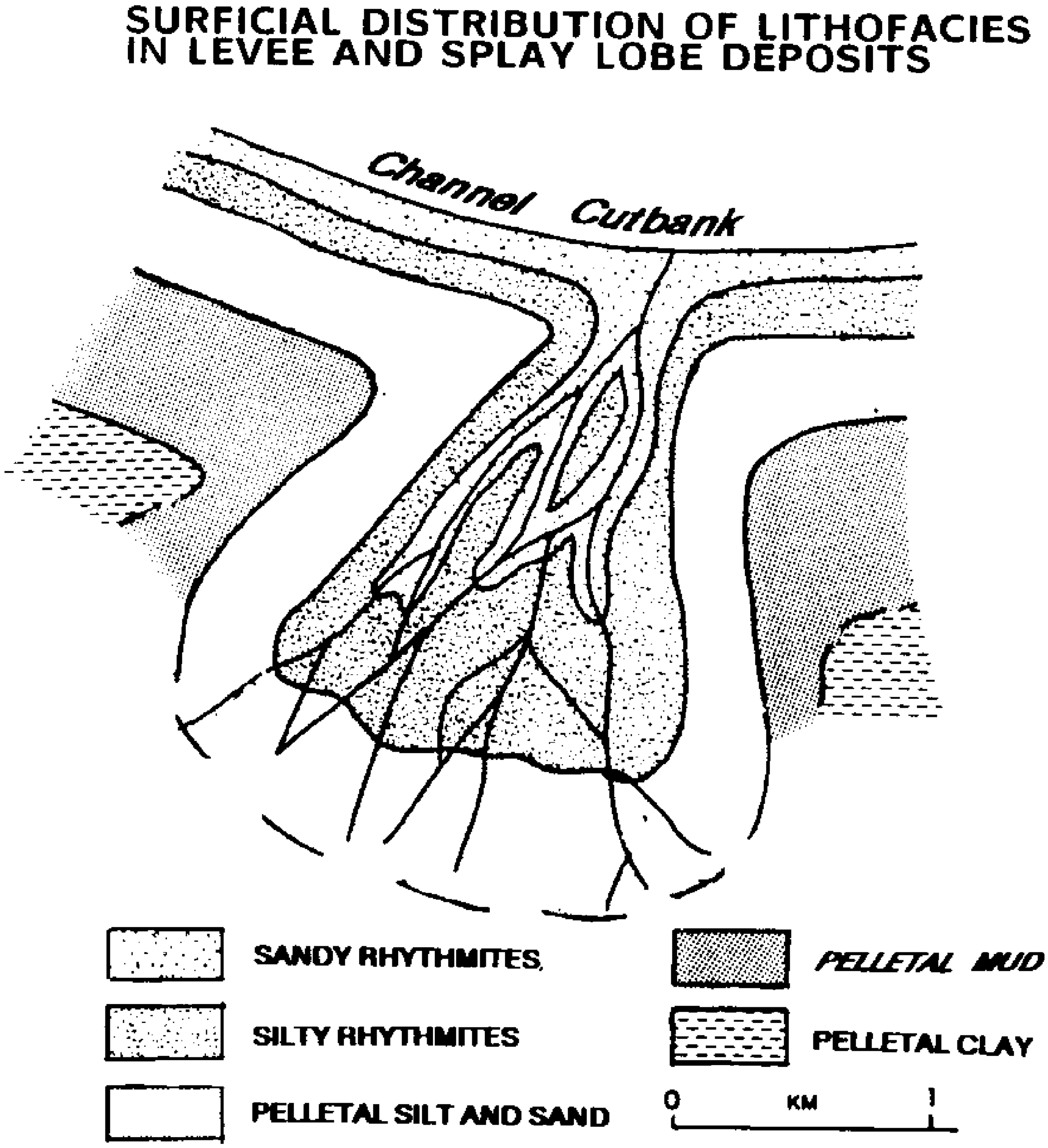


Fig. 42- Surficial distribution of lithofacies in levee and splay lobe deposits.

the most common grain sizes present in the coarse layers. Parallel laminations at the base of the coarse layer are replaced upwards by very small-scale ripple laminations and then a package of succesively finer graded laminations.

The stratification sequence can be interpreted in two ways according to experimental data relating mean size and mean velocity for flow depths of about 40 cm presented in Middleton and Southard (1977, p. 7.37). For a mean grain size of 0.1 mm: 1) a sheet flow emplacing parallel laminations under upper flow regime plane bed conditions (60-100 cm/sec) decelerates into a lower flow regime (less than 60 cm/sec) where ripple laminations are emplaced; as the current wanes below the threshold of movement successively finer graded laminae are emplaced during small surges; or 2) at very low velocities below the threshold of movement, parallel laminae are emplaced by successive pulses of decelerating sediment laden waters which increase in intensity over the flood; as flow velocity increases lower flow regime ripple laminations are emplaced, and as the flood wanes successively finer graded laminations are emplaced.

I favor the first interpretation. Dunes are missing primarily because the grain size is too small (very fine sand) and water depths are too shallow for dunes to form. At very shallow depths, with increasing velocity, ripples at small grain sizes (less than 0.1 mm) will change directly into upper flow regime plane beds and skip the dune phase (see Blatt, Middleton and Murray, 1980, p. 142).

With increasing distance from the sheet flood sources current velocities rapidly wane due to friction on a vegetated terrain. At intermediate distances from the source sand is replaced by more thinly layered silt with parallel and ripple laminations which is deposited from lower velocity currents. Silty rhythmites are typically more thinly interlayered than sandy rhythmites and grade distally into minutely (mm) interlaminated silt and clay which is easily disrupted by burrowers into massive appearing pelletal silt beds. Clay or mud layers are deposited from suspension distal to the source. Here a pair of coarse and fine laminations represents deposition from a single decelerating sheet flood. Thus the thickness of deposition associated with a single event, in this case, a sheet flood, decreases with increasing distance from the source.

Topography, Burrowing and Proximity to Source-- Primary sedimentary structures have a better chance of preservation near sheet flood sources because here rapid burial and thick deposition isolate lower layers from disturbance by burrowers. In addition to this, clay or mud layers deposited from suspension or as a drape left as the water table lowered are thinner in topographically high areas. Burrowing activity is restricted in topographically high dryer areas which drain faster after a flood and enhanced by puddle-like or damp conditions in low-lying areas closer to the flood basin. Thus sandy and silty rhythmites with well-preserved structures are common in a narrow band along the paleo-channel in levee deposits and along crevasses in splay deposits.

On distal topographically lower parts of the levee and on splay lobes, interlayering is thinner to start with and a short period of burrowing in predominantly silt-rich lithologies could effectively destroy nearly all primary stratification and generate pelletal silt beds. Pelletal silt grades basinward into pelletal mud and clay in the backswamp. The thickest (cm-dm) mud or clay intervals in a rhythmically bedded sequence obviously indicate prolonged periods of suspension sedimentation in a 'filled' flood basin and a distal source for the flood waters.

Graded Rhythmites-- The non-burrowed, graded rhythmites were probably deposited subaqueously as successive sheet floods entered anaerobic ponded water, decelerated and deposited a sequence of graded layers. Anaerobic conditions prevented burrowers from disrupting the primary stratification. The rooted layers at the top of graded layers indicate intervals between flood seasons.

Contacts Between Layers-- The presence of flame structures extending from the tops of fine layers up into the overlying sand layers suggests that recently deposited soft water-logged mud was inundated by a second sheet flood during the same season. Deposition of a sand layer over the incoherent mud allowed soft sediment deformation to take place in the form of flame structures. Sharp, horizontal contacts lacking disturbance by burrowers may also indicate rapid burial associated with multiple sheet floods.

Burrowed contacts at the base of sand layers accompanied by backfilled burrows that extend through a sand layer and up into the next adjacent mud layer may represent the escape of the burrowers after deposition from an upper flow regime sheet flow. This would explain the absence of a sharp contact at the base of the sand bed.

Recognition of Flood Events-- An annual flood season may include multiple sheet flood events that result in the deposition of a stack of laminates or rhythmic beds. Recognition of the end of an annual flood season in the stratigraphic record is difficult because bioturbation so pervasively disturbs primary stratification, because organic material which could serve to demarcate seasonal boundaries is so pervasively oxidized and missing from these deposits and because rooted mud layers that potentially can be used as seasonal indicators can be amalgamated.

Other Bioturbation Structures

Root Burrowed Silt-- There is a rare occurrence of a separate sediment fabric that consists of a mud-rich matrix, chocked full of small holes filled with silt. These holes may be vacated root burrows.

Dwelling Burrows-- Large dwelling burrows(?) or root traces which are up to 10 cm in diameter cross-cut both primary stratification and secondary (pelletal) fabrics (Fig. 39D, 39E, 39F, 37A). These structures are irregular in cross-section and may be partially lined by clay (Fig. 39F). Internal sediment consists of either mud pellets or rip-up clasts in a matrix of very fine sand and silt. Horizontal layering in the internal fill may be interpreted as either geopetal infilling or active backfilling by a burrower. These structures are large enough to be crawfish burrows or vacated tree root burrows.

Other burrows which are present but rare include 1) simple vertical U-shaped burrows with Fe-oxide linings and 2) backfilled vertical burrows with U-shaped meniscus structures which extend downward from bedding planes (Fig. 39D, 39E).

Root Structures and Organic material-- Besides a few sub-vertical root-hairs (1-3 mm diameter), organic material such as roots, wood, tree trunks and leaves is rarely preserved in levee and splay deposits because of rapid oxidation. Primary organic material is preferentially preserved in thick (cm) layers of mud or clay.

Relatively impermeable clay layers are the sites for concretionary overgrowths of iron-oxides or carbonates on root hairs. Simple root linings appear as bright hollow cylinders in the radiographs. Carbonate concretions up to a cm in diameter occur either singly with a root hair as nucleus or in chains when they nucleate on leaf fronds.

In backswamp clays (FB4), large gray root-mottles caused by tree root penetration commonly disrupt strata (i.e. Fig. 43D). These mottles are cm in width and up to several decimeters in apparent length. They are recognized in cores by their elongate, irregular shapes, and because the clay inside the mottle contrasts in color, grain size, and/or concretion content with the sediment outside the mottle.

The gray color indicates that reducing conditions are present in these localized zones. Fragmentary remains of tree roots or very fine particles of disseminated organic material may be incorporated in the gray zones (Fig. 43D). Slickensides and/or fragmented (?) clay may occur along mottle edges.

Retallack (1983A, 1983B) presented several hypotheses to explain the origin of similar zones of reduced sediment surrounding plant remains. Here, they are probably the result of both the anaerobic decay of roots in ground water after burial and illuviation of clays into the vacated root burrows. There is no evidence of geopetal infilling of the root burrows in X-ray radiographs. Brecciation of clay along mottle edges is probably caused by a combination of shrinking and swelling of clay, penetration by root hairs which are attached to tree roots and displacement of clays during penetration by

Fig. 43- X-ray radiographs (negatives) of backswamp deposits.

(See photograph on next page).

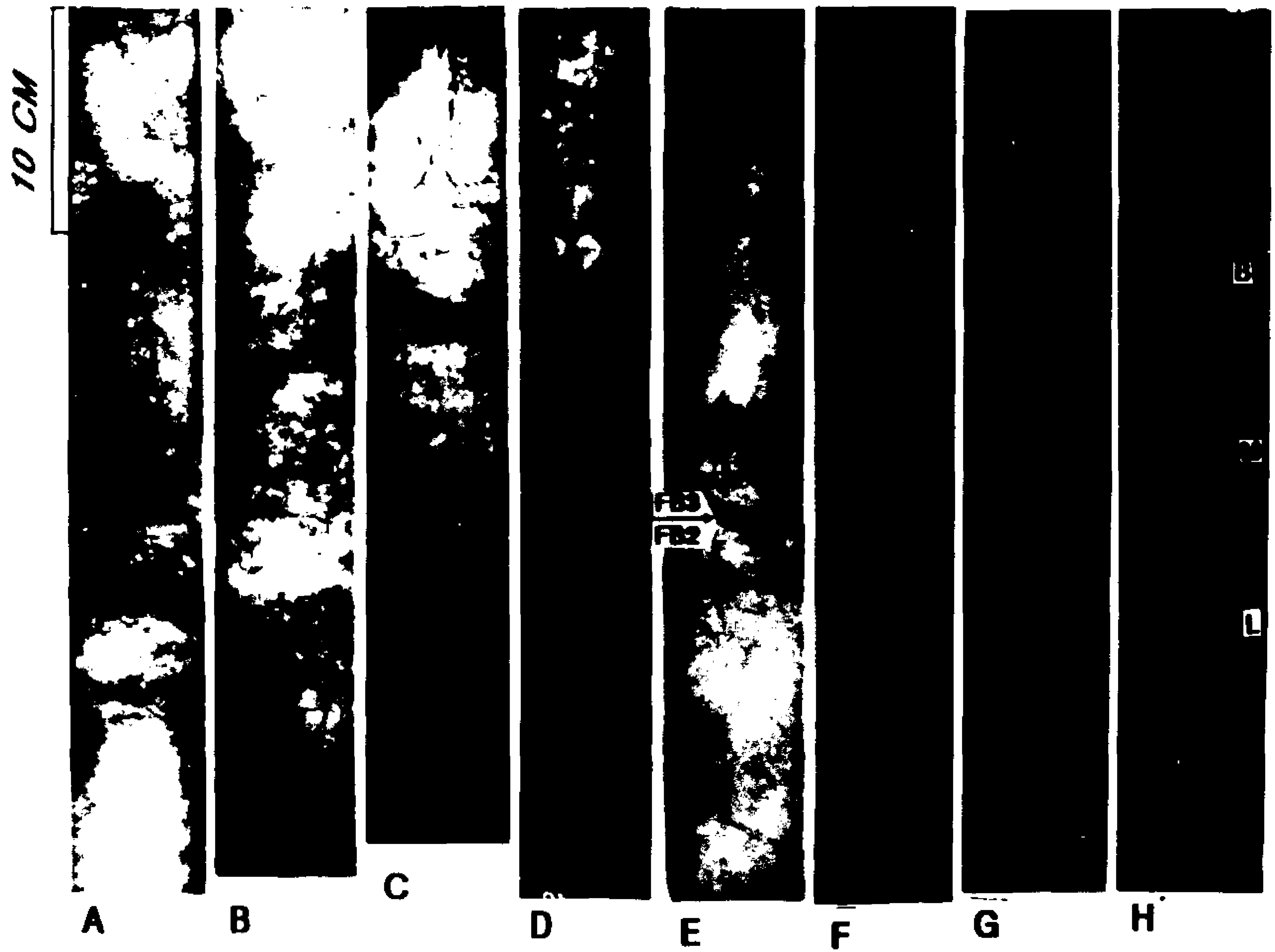
A,B,C,D. FB4: Typical backswamp rooted clays (FB4). Note mottling caused by patches of clay with concretions (light colored patches) and concretion-free clay (dark gray patches). Large patches of dark gray concretion-free clay are large clay-filled root burrows (D). Granular Fe-oxides associated with pelletal fabrics show up well in C and D as faint circular patches. Tree roots are black patches (D) and fine root hairs without concretionary linings occur as black wiggly lines. (A and B: Core 69; C and D: Core 68).

E. Contact between the mudball conglomerate (FB3) and underlying sandy clayey silt (FB2) shows interpenetrating lithologies and a preponderance of mudballs. Both units have a concretionary fabric indicated by the light patches in the radiograph. (Core 68).

F. FB2: Massive clayey silt with Fe-oxides in the upper part of the radiograph. (Core 66).

G. The contact between the dark blue clay (FB1) and the overlying clayey silt (FB2) lies below the black organic debris. In the lower part of this radiograph, granular Fe-oxides appear in FB1 as fuzzy white patches. Above the contact, FB2 is structureless and devoid of concretionary material. (Core 66).

H. The dark blue clay (FB1) at the base of the sequence includes twigs (black), leaf layers (L) (black pencil-thin lines), and burrows? (white, vertical lines) lined with pyrite druses (B). Mottled horizons indicate a burrowed substrate (M). (Core 66).


10 CM
FB3
FB2
A
B
C
D
E
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H

tree roots.

Summary of Bedding Types

Figure 44 shows the condition of rhytbmites as a function of progressive disturbance by burrowers. Ideal rhythmites consist of well-stratified sand or silt layers that fine upward into mud or clay (Fig. 44A). If the suspension layer at the top of the cycle is thin, sandy rhythmites may consist of ripple-laminated sand beds separated by burrowed mud-rich drapes (Fig. 44B). Each drape is completely burrowed into a pelletal fabric. Where rhythmites have thicker suspension layers, thick, densely burrowed, pelletal muds separate partially disrupted crossbedded sands. Only traces of the original bedding may be preserved if a wormy fabric is present (Fig. 44C). In more thinly layered rhythmites or laminates, burrows in the finer layers completely obliterate sedimentary structures to form rather homogeneous-appearing pelletal silt (Fig. 44D). If original stratification consists of alternating minute laminations of clay and silt, such as is common in backswamp deposits, a pelletal mud will develop.

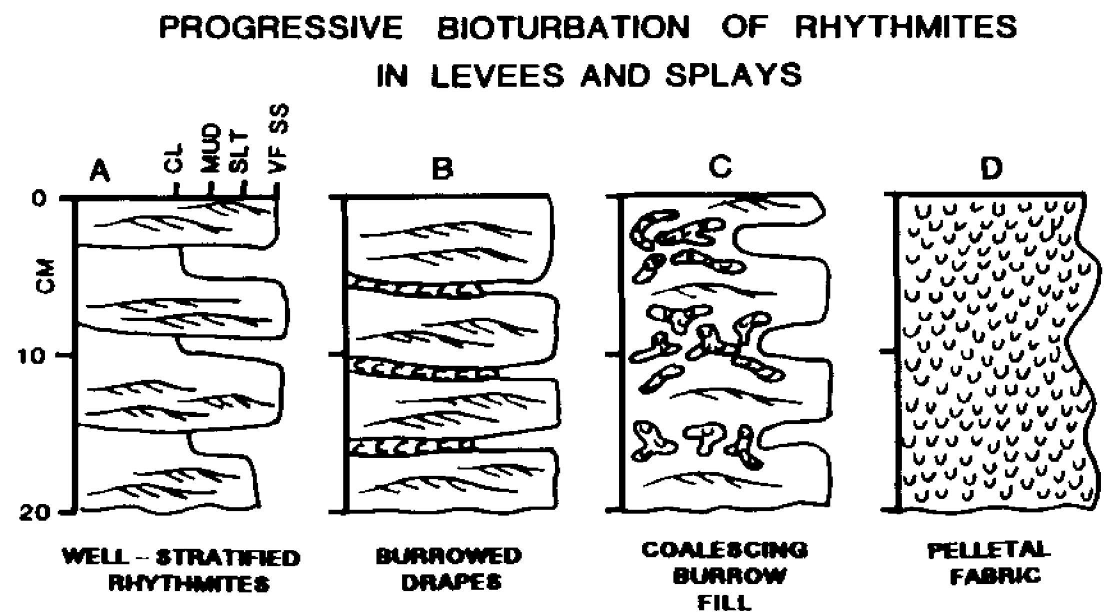


Fig. 44- Conditions of rhythmites as a function of progressive disturbance by burrowers.

STRATIGRAPHY

Units

The principal backswamp units include from the base upward: 1) FB1: dark blue clay with leaf layers, 2) FB2: massive very fine sandy clayey silt, 3) FB3: mudball conglomerate, and 4) FB4: rooted clay (Fig. 45).

The sequence associated with levee/splay progradation into the flood basin is about 8-10 m thick maximum (Fig. 46). The base of the sequence is marked by the change in lithology from dark blue clay (FB1) to a burrowed silty clay (FB5). Additional levee and splay units include: 1) FB6: rhythmically layered silt, 3) FB7: pelletal silt, 4) FB8: dark-brown pelletal mud, and 5) FB9: rhythmically layered sand, silt and clay. The term, 'proximal', refers to levee or splay deposits which are adjacent to the paleochannel. 'Distal' refers to levee and splay deposits which are distal to the paleochannel.

Crevasse-fill is divisible into five units (CV1 thru CV5) emplaced during seasonal or sporadic flow conditions in discrete channels (Fig. 47).

Backswamp

FB1--Dark Blue Clay-- The deepest unit encountered consists of bluish-gray clay (Fig. 48, 43H). Locally it has intercalations of silt and macerated organic debris. These organic-rich zones occur at intervals approximately 1 to 1.5 cm apart and consist of several leaf layers with minor woody material interlaminated with clay. The silt layers are locally burrowed into wispy-appearing diffuse layers. Vivianite nodules and tiny rootlets with probable pyrite druses are also present (Fig. 43H). The layers of organic debris are not present

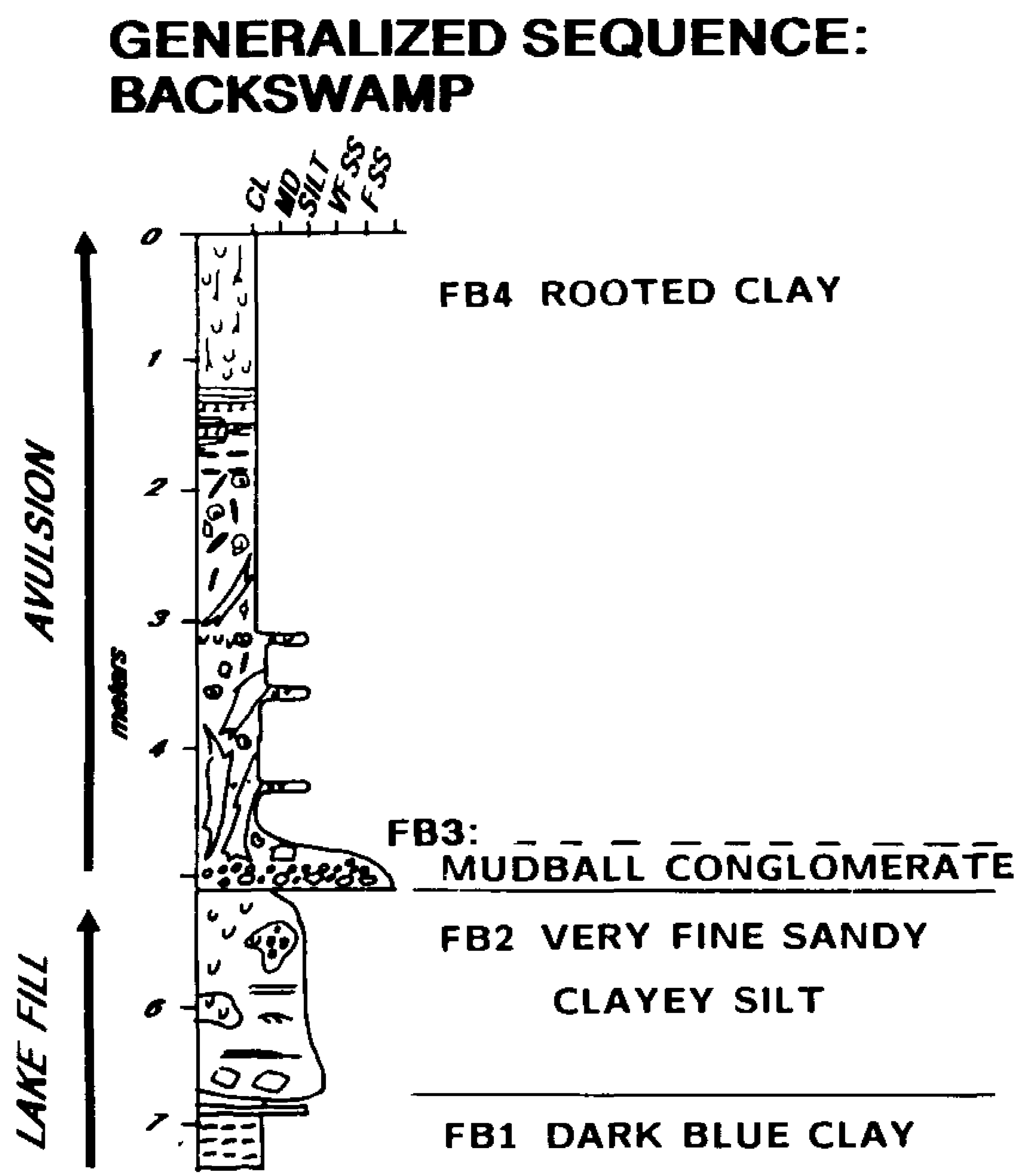


Fig. 45- Stratigraphic sequence in backswamp deposits.

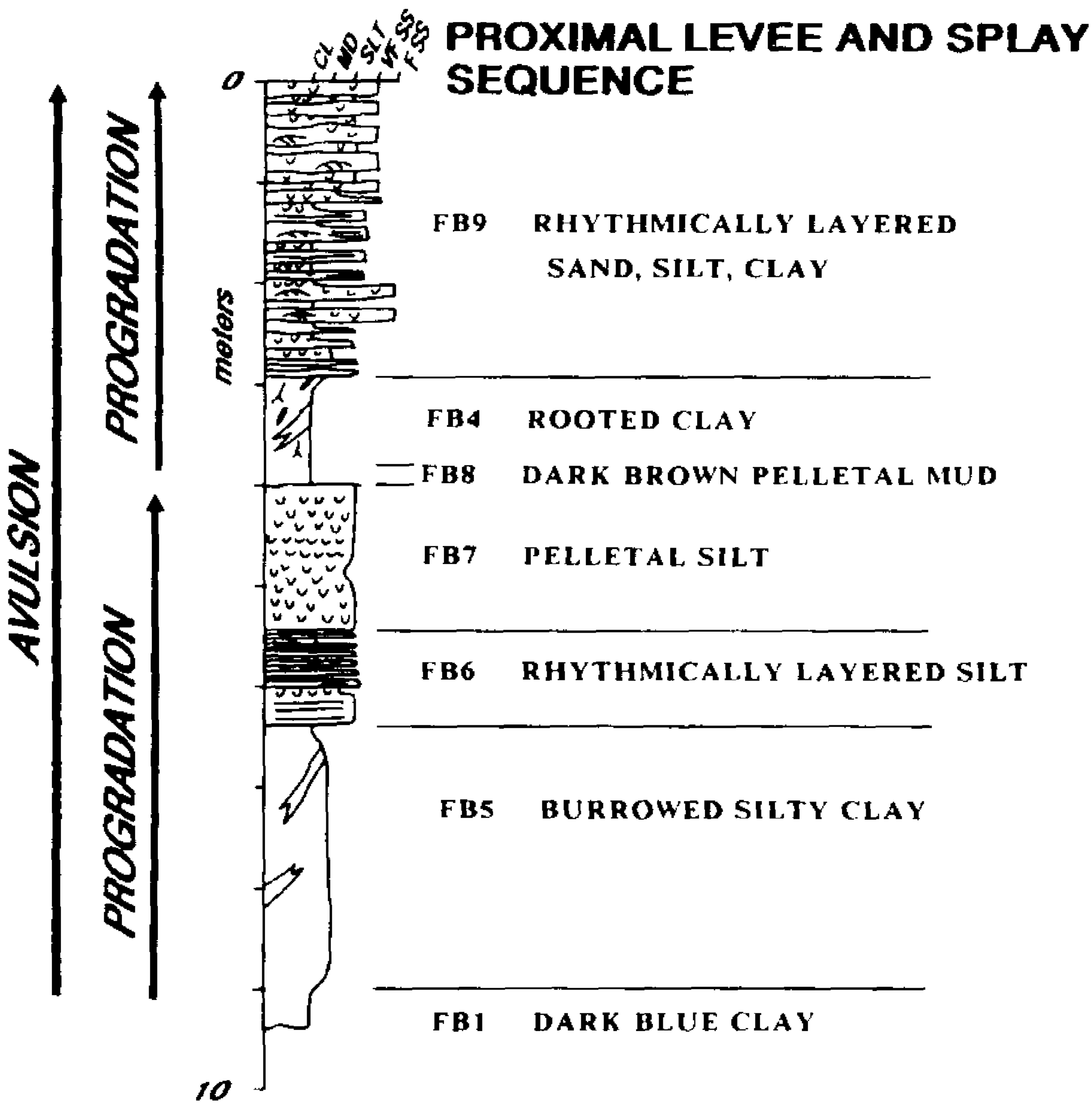


Fig. 46- Stratigraphic sequence in levee and splay lobe deposits.

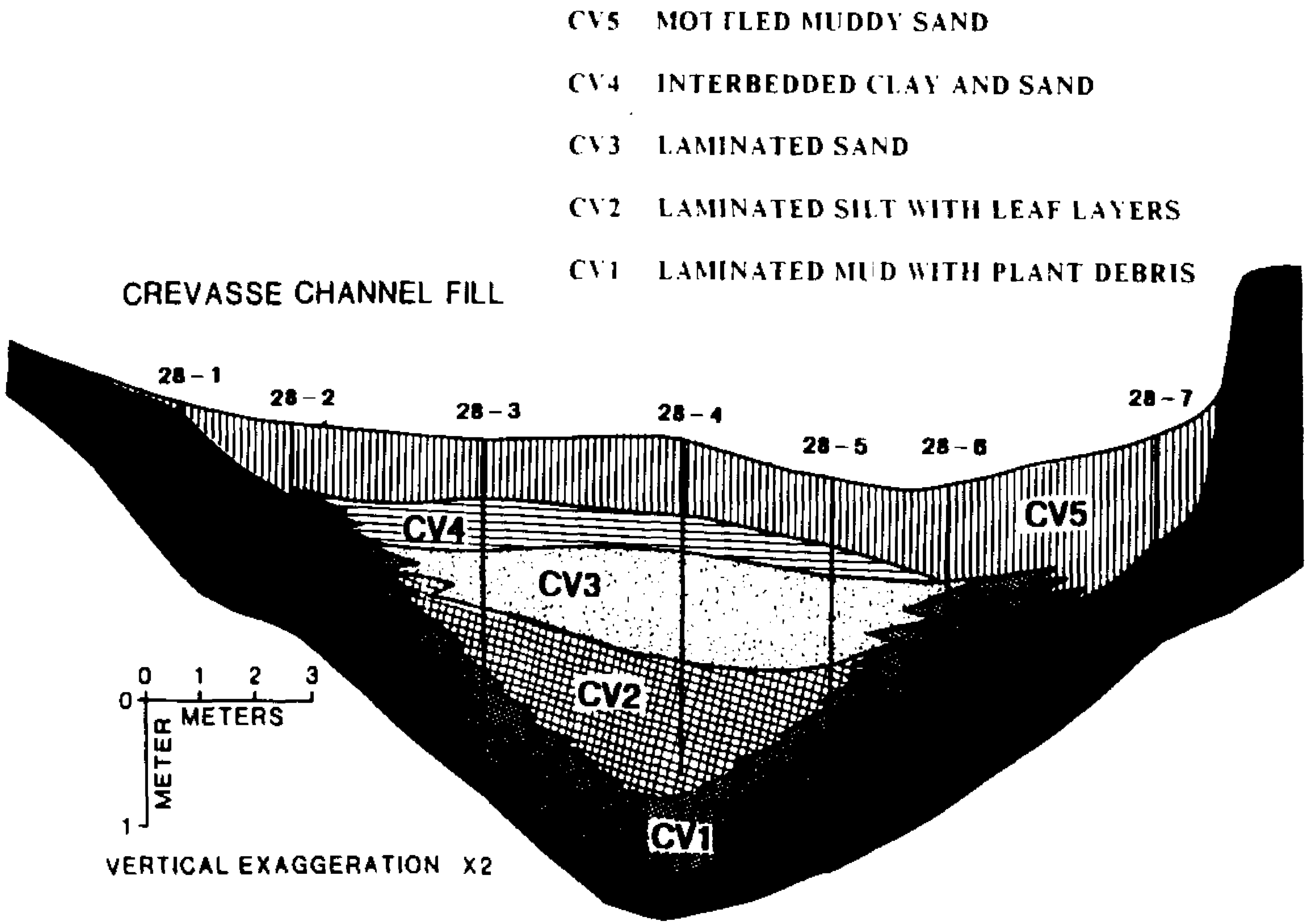


Fig. 47- Cross-section through crevasse channel fill at site CV-28. This profile is part of splay profile E-E' (Fig. 30, page 77).

FLOOD BASIN UNITS: BACKSWAMP DEPOSITS

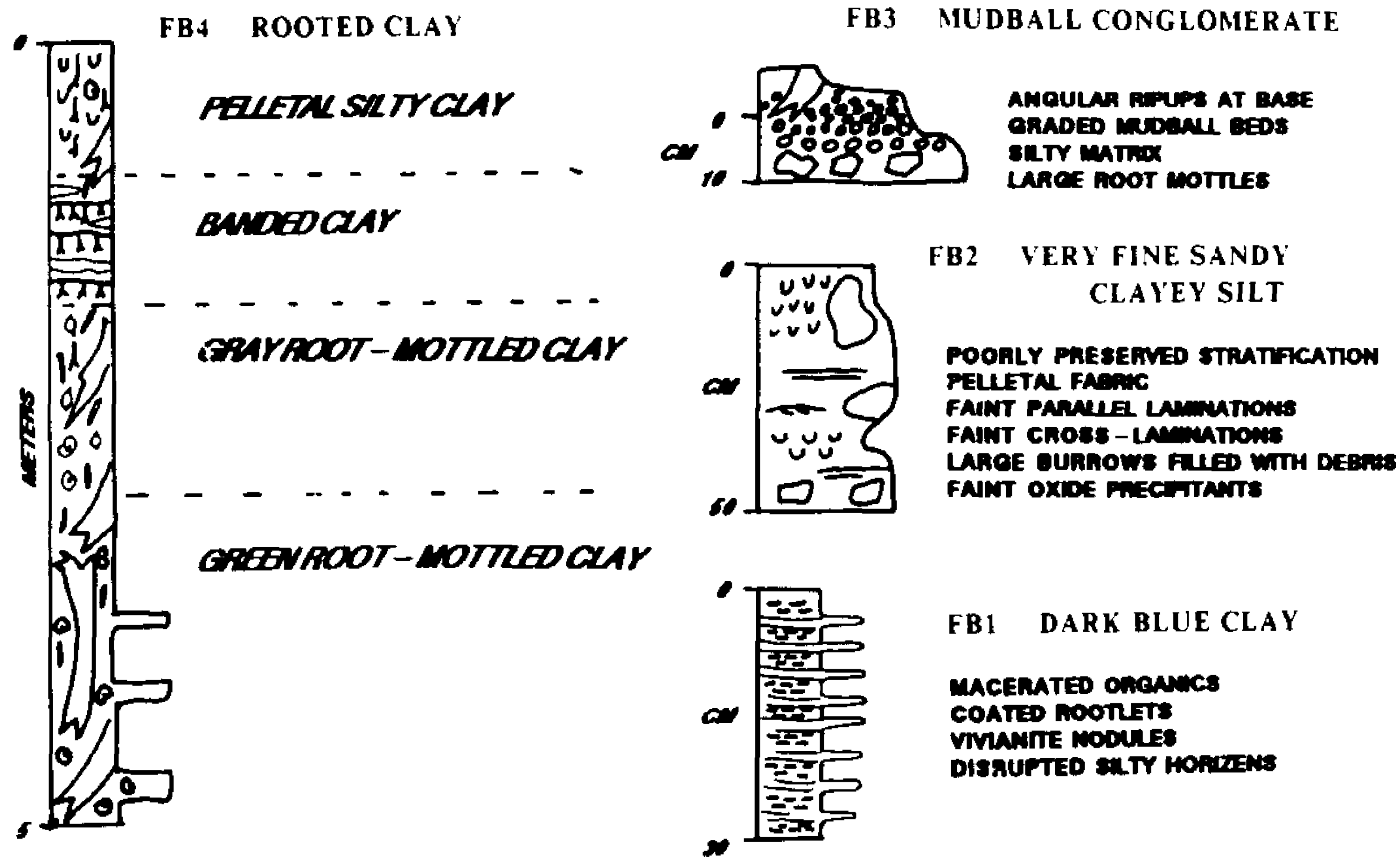


Fig. 48- Lithologic characteristics of backswamp units.

in every core.

In the backswamp, these clays are overlain by a narrow zone (10 cm thick) of rooted clay/silt laminates with probable iron-oxides as root linings (Fig. 43G). These are in turn overlain by the coarser grained silts and sands of unit FB2.

FB2--Very Fine Sandy Clayey Silt-- This unit consists of massive-appearing, slightly clayey, burrowed, pale-green, very fine silty sand and sandy silt (Fig. 48, 43E, 43F, 43G). Patches of dark-gray, organic-rich clay representing either rip-up clasts or infillings of vacated root burrows (Fig. 43G) are present at the base of the unit. Primary stratification is present only as sporadic zones of faintly laminated silt or more rarely, as single faint cross-sets in very fine sand.

Large burrows, 3-4 cm in diameter, with partial clay linings and a faint geopetal (?) or meniscate (?) structure cross-cut bedding. The burrows are filled with debris such as clay balls, loose silt, and partially cemented silt clasts. Faint precipitates of iron-oxide (Fig. 43E, 43F) and oxide-rich clay films (argillans) segregated by illuvial processes are also present.

FB3--Mudball Conglomerate-- This unit consists of unconsolidated clay or mud clasts (2 cm maximum diameter) in a matrix of silt and smaller rip-up clasts (Fig. 48, 43E). A sharp contact separates this unit from the underlying silty sand (FB2) (Fig. 43E). The clasts are angular to rounded and exhibit a variety of colors.

In one excellently preserved bed about 25 cm thick (Core 65, Fig. 22A), the mudball conglomerate appears to be normally graded. Matrix-supported angular mudballs up to 2 cm in diameter in a silt matrix fine upward into medium-grained, well-sorted, clast-supported mudballs at the top. This bed may actually consist of several upward-fining beds rather than one thick bed. Bedding planes in clay-rich beds are difficult to resolve.

This unit changes up-section into a highly jumbled section of interpenetrating clay-rich lithologies which make it difficult to delimit the actual contact between the conglomerate (FB3) and overlying rooted clay (FB4) (Fig. 48). Even the lower part of FB3 consists of the interpenetrating lithologies (Fig. 43E). Here the silt matrix between the mudball clasts transmits more moisture to the clays so that they are wetter and more plastic than the overlying rooted clays (FB4). Pressure from coring may have mobilized the plastic clays so that they flowed to form the jumbled zone. The jumbled lithologies could also represent 1) slumping into vacated root burrows, or 2) mottling due to an extensive root burrowed deposit.

FB4--Rooted Clay-- A thick (5 m) rooted clay occurs as the superficial unit in the backswamp sequence (Fig. 48, 43A, 43B, 43C, 43D). The main characteristics of this clay are: 1) poorly preserved primary stratification, 2) extensive root-mottling, 3) carbonate nodules and 4) oxide precipitates. It ranges in color from green to gray to brownish gray with decreasing depth. Shale or clay color is possibly correlated with carbon content and the ratio Fe^{+2}/Fe^{+3} (Potter, 1980). Primary stratification is obliterated by burrowing, root-mottling caused by tree root penetration, small root hairs, and even dense nodule formation. Pelletal mud and pelletal clay are common facies, with sporadic layers of pelletal silt. The evidence of primary stratification is in the form of 1) unburrowed remnants of clay/silt laminates, 2) rare layers of macerated organic debris, 3) leaf fronds separating clay layers, and 4) rooted horizons.

Although vertically oriented root hairs (up to 2 mm in diameter) are ubiquitous, macerated debris such as twigs, wood chips and leaf fragments is preserved only rarely in discontinuous horizons. Primary organic debris appears black in X-ray radiographs (Fig. 43D).

Carbonate and iron-oxide minerals are common precipitates. The sites and occurrence of mineral precipitation is partially controlled by the presence of burrowed fabrics and organic material. The early diagenesis of nodules and precipitates in backswamp deposits is discussed in detail by Ho and Coleman (1969) and Coleman (1966).

Secondary mineral coatings and replacements allow organic material that would otherwise be oxidized to be preserved as 'fossil' casts of the original organic material. Root hairs commonly have either carbonate or iron-oxide coats which appear in X-ray radiographs as thin bright, rod-shaped linings with sharp boundaries. If thick enough, carbonate coatings may develop into nodule-forms up to 1.5 cm in diameter. Carbonate nodules appear as extremely bright blurs without sharp outlines in radiographs.

Mineral coatings are present on: 1) isolated sub-vertical root hairs, 2) vertical root hairs (0.5 mm diameter) arranged in rows that terminate upward along irregular horizons or, 3) leaf fronds along partings that appear as as reticulate networks of tiny hollow rods (dimensions of 0.4 mm diameter X 3.0 mm in length or chains of carbonate nodules.

Granular iron-oxides are commonly concentrated in the silt-rich matrix between the pellets in burrowed fabrics. In radiographs, individual granules are clustered into ovate zones (0.5-1.3 cm in diameter) which are present as faint, diffuse appearing white-ish blurs (Fig. 43C, 43D). The burrow forms and pelleted backfill are rarely visible.

This unit is pervasively cross-cut by elongate, irregularly shaped root-mottles (cm X dm) caused by tree root penetration (Fig. 43D). The gray clay inside the mottle often contrasts in color, grain size, and/or concretion content with the sediment outside the mottle. Fragmentary remains of tree roots or very fine particles of disseminated organic material may be incorporated in the gray zones. Slickensides and/or fragmented (?) clay may occur along mottle edges. The root-mottles are usually concretion-free but penetrate clay with carbonate nodules, root linings (carbonate and iron-oxide), coated leaf fronds(carbonate) and pelletal facies with granular iron-oxides.

The rooted clay (FB4) tends to coarsen up-section near the paleo-channel by grading from clay to mud and by the addition of silty or sandy horizons. It can be subdivided into four subunits (Fig. 48).

The lowermost subunit, FB4A, consists of pale green clay with abundant concretionary material and sporadic silty horizons which decrease in thickness and become rarer upsection. It is extensively cross-cut by the gray, relatively concretion-free root mottles. Granular oxides are concentrated in burrowed fabrics in the 'host clay. It is gradational with the overlying subunit.

FB4B consists of extensively root mottled gray clay which lacks distinct silt horizens. Carbonate linings and nodules are very abundant here especially outside of the root mottles.

FB4C is a gray clay with carbonate coated leaf fronds. Locally, red banding is associated with the coated leaves. The red bands are discontinuous and irregular in thickness.

FB4D is a brownish-gray mud with a burrowed, or pelletal fabric. Remnants of silt and clay laminations are present sporadically.

Levee and Splay Lobe

FB5--Burrowed Silty Clay-- (Fig. 38A, 38B)-- Massive to burrowed bluish-green silty clay overlies FB1 (Fig. 30C, Fig. 22A). Locally it is silty enough to be called clayey silt. It is mottled appearing in radiographs because light patches of granular iron-oxides are associated with pelletal fabric. Nodules are not present and coated root hairs are rare. Primary stratification probably consisted of interlaminated silt and clay or silty rhythmites.

FB6--Rhythmically Layered Silt-- (Fig. 38C, 38D, 38E, 38F)-- FB6 is principally a well-stratified, yet burrowed silt. The rhythmic nature of the bedding is obvious with burrows concentrated in clay or mud layers. Small-scale cross-stratification and parallel laminations are well preserved in sand and silt layers. Silty rhythmites are the most common facies but burrowed silt/mud laminates, pelletal silt layers, sandy rhythmites and a few rooted clay layers are also present. In rare occurences, thick beds (10-30 cm) of non-burrowed cross-stratified very fine-fine sand are present (Fig. 38F). Large burrows cross-cut the burrowed laminates and rhythmites (Fig. 38F).

FB7--Pelletal Silt-- (Fig. 35A, 35B, 35C, 35D)-- The well-stratified silt (FB6) is succeeded upsection by a slightly clayey, sandy pelletal silt with a few remnants of parallel laminations or ripple forms. Sporadic silt/mud laminates have burrowed muddy horizons. Granular iron-oxide precipitates are associated with the pelletal fabric (Fig. 35B, 35D). Large burrows that cross-cut the pelletal fabric are common. This unit grades upward over a vertical distance of several cm from pelletal silt into a dark brown, organic rich mud (FB8) or a gray rooted clay (FB4).

FB8--Dark Brown Pelletal Mud-- (Fig. 35E, 35F, 35G, 35H)-- This dark-brown organic-rich pelletal mud can be traced fairly extensively as a marker bed and has gradational contact with the underlying and overlying units (Fig. 35E, F, H). Its brown color is probably a diagenetic phenomenon related to oxidation of a relatively thick A horizon that developed during a prolonged period of non-deposition. If cores are allowed to oxidize, multiple dark brown layers may appear in FB4, the overlying unit, as well.

This pelletal mud includes well-preserved coalescing masses of pelleted burrow fill with overlapping meniscate structures (Fig. 35E). Remnants of minutely interlaminated (1 mm) fine silt and brown clay are present. Granular iron-oxide concretionary material is associated with coarser parts of the pelletal fabric (Fig. 35H).

FB9--Rhythmically Layered Sand, Silt and Clay-- (Fig. 37, 39, 40B)-- FB9 consists principally of sandy rhythmites, silty rhythmites and pelletal silt which exhibit the proximality trend in stratification. Graded rhythmites, laminated sands, rooted muds and interlaminated silt and mud are also present.

A sharp contact overlain by a coarser layer with basal mudballs is present at the base of the unit (Fig. 40B, 49). Locally (along proximal splay profiles C and D) the unit interfingers with rooted clays (FB4) which split it into an upper and lower zone (Fig. 30).

Agriculture has modified the upper 20 to 50 cm of this unit.

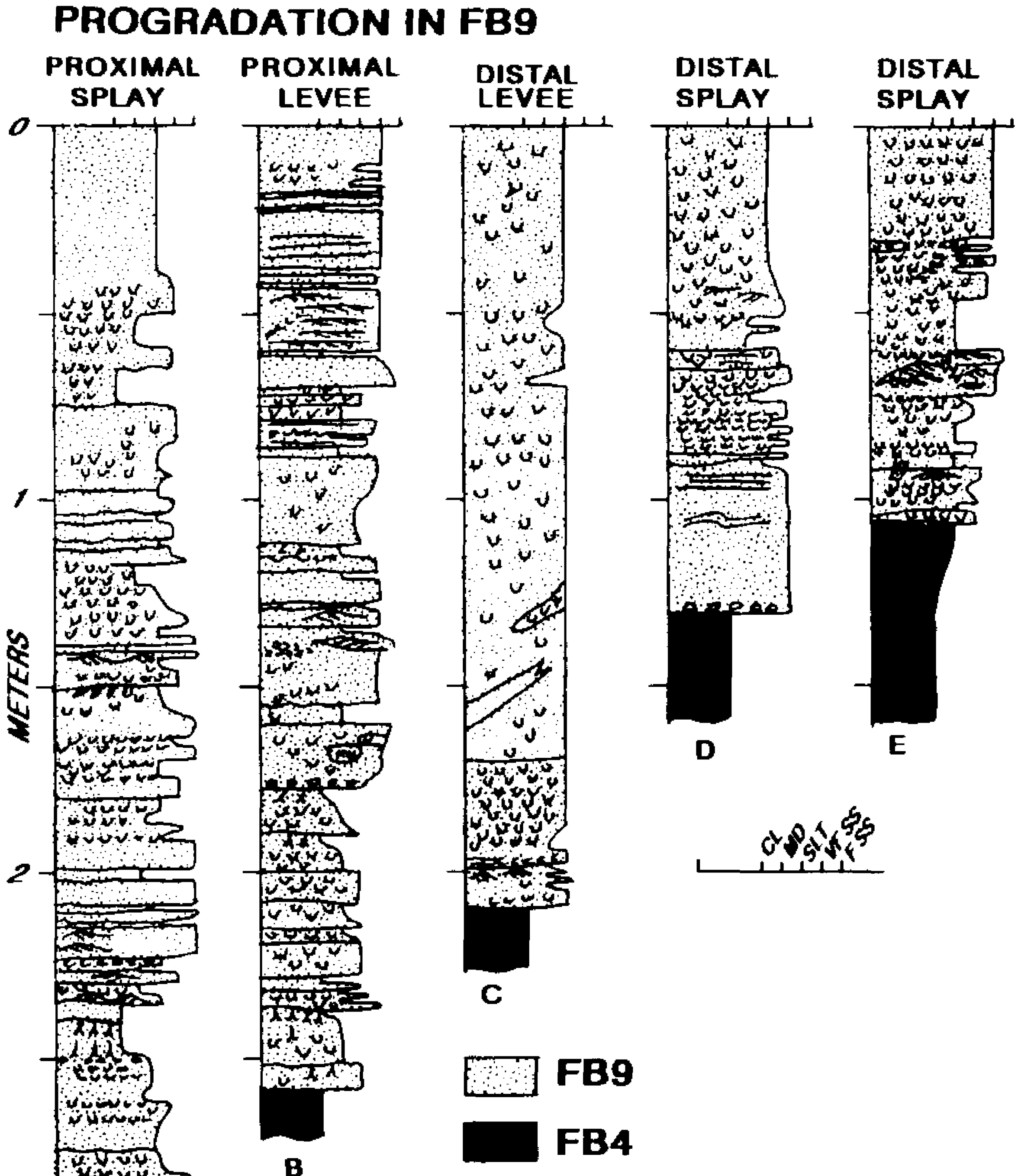


Fig. 49- Progradation in FB9.
A. Proximal splay lobe. (Core 44).
B. Proximal levee. (Core 72).
C. Distal levee. (Core 76).
D. Distal splay lobe:
Fining-upward Sequence (Core 101).
E. Distal splay lobe:
Coarsening-upward sequence (Core 54).

However the unit is highly variable and is stratigraphically complex with a definite structure to its variation. Both lateral and vertical variation are related to to distance from the sources of sheet floods. This has been discussed in great detail in the previous section entitled, 'Sedimentology of Sheet flood Deposits' and is briefly summarized below.

With increasing distance from the source of the sheet flood, the bedding types change in a predictable manner in the upper part of the unit: 1) sandy rhythmites are replaced in succession by silty rhythmites, and pelletal silts (Fig. 41), 2) the thickness of the rhythmic beds tends to decrease, 3) the intensity of disruption by burrowers increases, and 4) grain size decreases. Distal to sheet flood sources pelletal silts grade into pelletal mud and clay of the backswamp.

Thus the thickest, least burrowed, best-stratified sandy rhythmites with well-developed cross-stratification (10 cm thick sands) are present in the upper part of FB9 in narrow zones along the paleo-channel levee and crevasses close to their origination points. Here silty rhythmites, pelletal sand and pelletal silt beds are also important but subordinate to the dominating sandy rhythmites. The lower part of FB9 in proximal splay deposits is more extensively burrowed into pelletal silt.

The most thinly interlayered and extensively burrowed rhythmites (and laminates) and the thickest pelletal silt beds occur distal to the paleo-channel in levee deposits and distal to crevasses in splay lobes. Here sandy and silty rhythmites are minor components.

While the surficial part of FB9 is increasingly more burrowed and less stratified with increasing distance from the sheet flood source, stratification in the lower part of FB9 becomes better preserved closer to the flood basin. Well-stratified silty rhythmites, graded rhythmites and burrowed laminates are present here as well as some of the thickest sequences of non-burrowed cross-stratified sands. These well-stratified deposits are often succeeded upsection by thick pelletal silts in distal levee or splay deposits.

Crevasse Channel Fill

CV1--Laminated Mud With Plant Debris-- (Fig. 50A)-- The unit at the base of the channel fill sequence consists of dark gray mud and abundant organic debris (Fig. 51C). A thin basal lag (cm) of wood chips, mudballs, twigs and/or shell hash (Fig. 51C, 52C, 52D) is overlain by interlaminated mud and macerated leaves and small twigs (Fig. 51C). These laminations drape larger branches and wood fragments.

Above this are clay/leaf laminates lacking large chunks of wood. The strata between the basal lag and the top of the clay/leaf laminates form an upward-fining cycle (Fig. 50A). A similar upward-fining cycle overlies this basal cycle. Above this are several beds of rip-up clasts which are separated by clay laminations or silt/leaf rhythmites. Examples of beds of ripup clasts that are present in crevasse fill are shown in Figures 52E, 52F, and 53F. The unit is topped by a layer of wood.

CV2--Laminated Silt with Leaf Layers-- (Fig. 50B)-- CV1 is overlain by a laminated silt with leaf layers (Fig. 51B, 51C). Wood fragments are not present here. Sporadic mudball horizons and ripple laminated layers (1 cm thick) are interbedded with the laminated

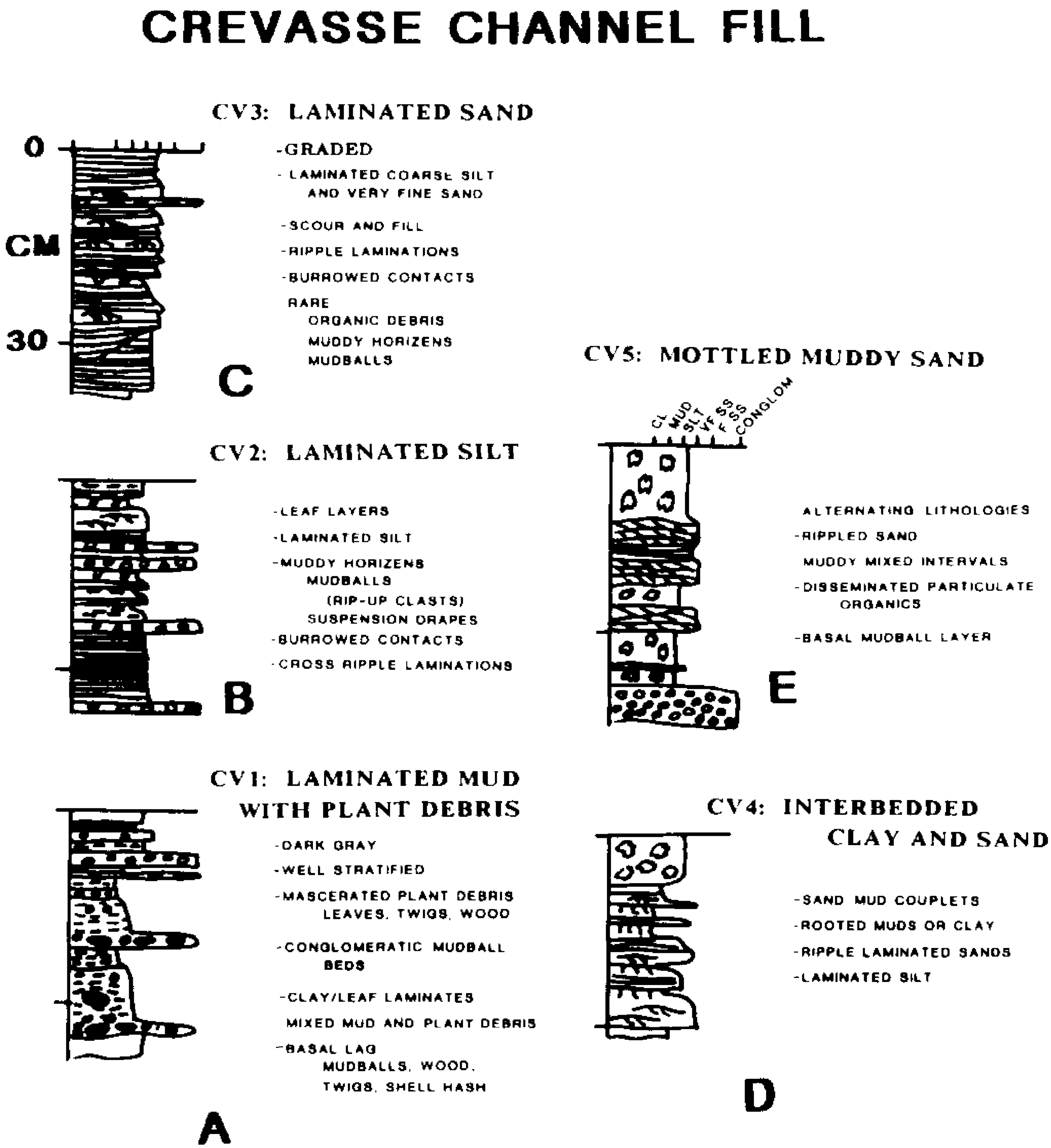


Fig. 50- Crevasse channel fill units at site CV-28.

Fig. 51- (See next page).

A. Set of photographs showing stratification in surficial splay lobe deposits. Here FB9 overlies FB4 and consists of pelletal silt, pelletal mud, and burrowed rhythmites with traces of small ripple laminations. Portions of this core are shown in greater detail in Figures 38 and 39. (Core 54, Approximate Depth: 20-140 cm).

B. Sequence of units in crevasse channel core CV-28-4. Figure 50 shows descriptions of crevasse channel units.

C. Sequence of units in crevasse channel core CV-28-5. Figure 50 shows descriptions of crevasse channel units.

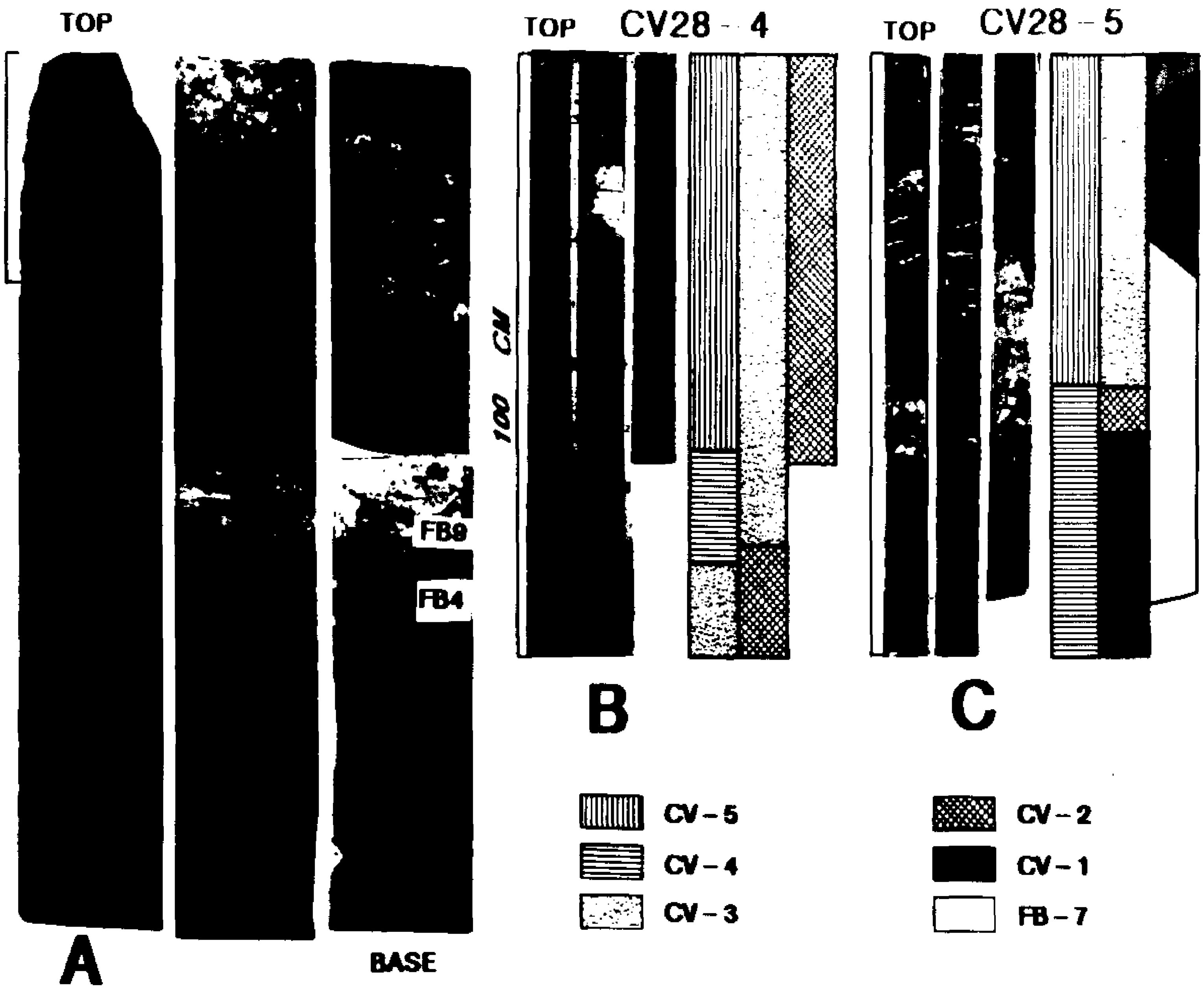

TOP
CV28 - 4
TOP
CV28 - 5
TOP
100 CM
FB9
FB4
BASE
A
B
C
CV - 5
CV - 4
CV - 3
CV - 2
CV - 1
FB - 7

Fig. 52- Crevasse channel fill. (See next page).

A. Photograph of slab showing complexly interlaminated very fine sand, silt, clay and organic debris which is typical of crevasse channel fill. (Core 8, 100-140 cm).

B. X-ray radiograph of same slab in A. Organic material appears black.

C. Photograph showing contact between the crevasse channel fill sequence and the underlying pelletal silt (FB7). (Core 8, 140-180 cm).

D. X-ray radiograph of same slab shown in C.

E. Interlayered stratified mudball beds (dark) and very fine sand and silt beds. Mudballs are mixed with organic debris. Sand beds also include mudballs which are aligned along traces of foreset laminations outlined by leaves draping very small ripple forms. The leaves appear as black lines in the photograph.

F. The dark gray mud-rich bed in this photograph is actually a bed of ripup clasts. The largest ripup clast is about 2 cm in diameter and is light colored relative to the finer grained matrix.

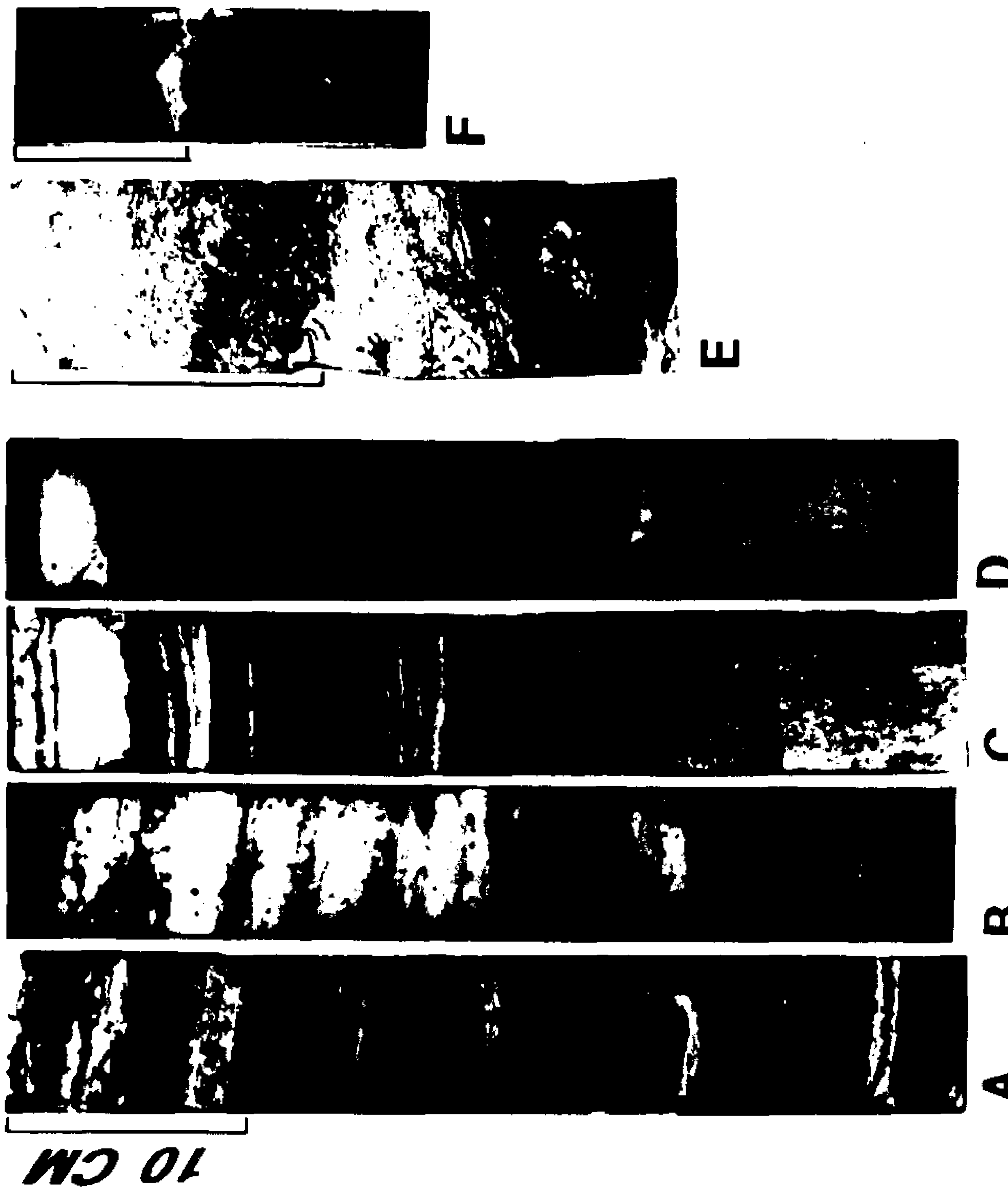

A
B
C
D
E
F
10 CM

Fig. 53- X-ray radiographs of crevasse channel fill, Core CV-19.

A. 0-40 cm: Mottled organic-rich muddy sand and lighter silt.

B. 40-80 cm: Organic debris such as twigs, stems and leaf horizons appear black in the radiograph.

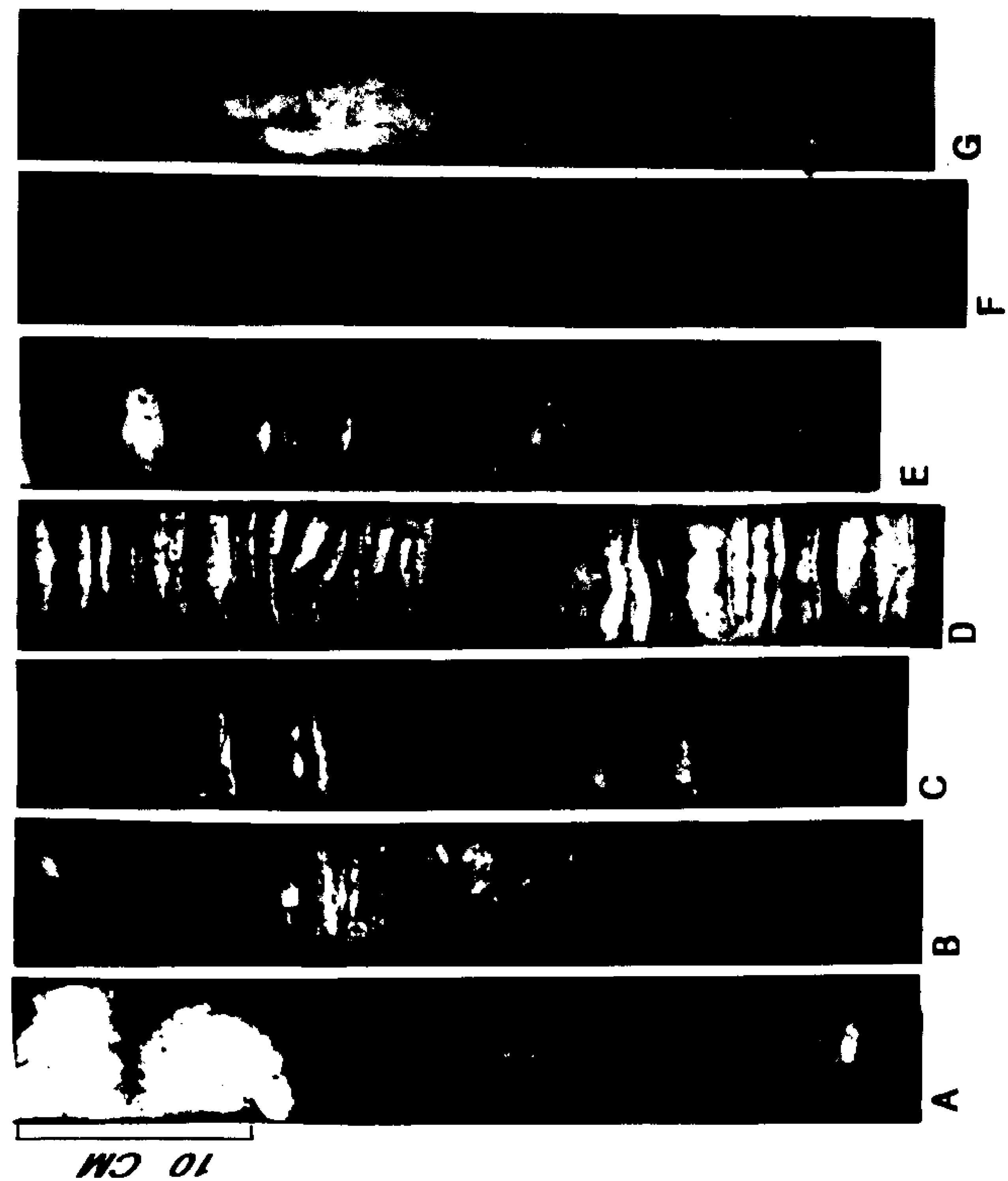
C. 80-100 cm: Twigs appear as black patches. Graded silt layers and complexly interlaminated clay, silt and leaf layers are also present. Soft sediment deformation was probably caused by vibracoring.

D. 100-140 cm: Packages of graded silt laminations are separated by darker colored organic-rich horizons that contain particulate organics and leaves.

E. 160-200 cm: Thick graded silt laminations up to several cm thick are present. Packages of graded laminations are sporadically separated by organic (detrital) and clay-rich laminations which appear as dark gray lines in the radiographs. Detrital organics also occur as leaf layers (black horizontal lines) and as random twigs and particulate debris (black specks). Very small ripple forms are present in the silt or very fine sand near the 20 cm scale.

F. 200-240 cm: The base of the crevasse channel fill lies at the bright white spot which is a concretion. Below this is the pelletal silt of FB7. The coarse debris above the contact consists of ripup clasts and small twigs in a muddy matrix. The ripup clasts appear as very faint rounded light spots in the radiograph.

G. 240-280 cm: Pelletal silt of FB7.


A
B
C
D
E
F
G
10 CM

silts. Silt laminae or, more correctly, silt layers are normally graded and range in thickness from less than 1 mm to 2 cm (Fig. 53E, 53E). Leaf layers separate either individual graded silt laminations or a set of graded silt laminations. The laminations comprising a set demarcated by leaf layers may thin upward in a regular fashion. Sets of silt laminations may also topped by a mud with a burrowed upper contact. Other cores not on the cross-section being discussed exhibit intricately interlaminated silts and clays with iron-oxide coated roots in the clay laminae (Fig. 52A, 52B, 52C, 52D, 53C, 53D, 53E)

CV3--Laminated Sand-- (Fig. 50C)-- This unit consists of laminated or ripple laminated very fine sand and coarse silt (Fig. 51B, 51C). Organic debris is entirely absent. Mud or clay horizons and beds of rip-up clasts are rare. In this unit laminations also range in thickness from about 1 mm to 2 cm. Locally, the laminations are truncated by scour and fill structures. Here laminations may occur in sets similar to those described above. For example, a single sedimentation cycle may consist of normally graded layers which are 2 cm thick at the base of the set and which get progressively thinner up-section.

Sedimentation cycles may also consist of laminated sand that fines upward into laminated silt and then into a thin layer of slightly clayey silt. Sporadic burrowed contacts are present at the top of these clayey silts. The burrows are vertical, about 1 mm in diameter, and up to 6 mm in length. They are filled with sand from the overlying layers.

CV4--Interbedded Clay and Sand-- (Fig. 50D)-- This unit consists of interbedded clay and sand or silt (Fig. 51B, 51C). Small-scale fining-upward cycles are present. Complete cycles consist of a basal ripple laminated sand which fines upward into parallel laminated silt and then into clay. Other cycles consist of laminated silt fining-upward into clay. The clay layers are rooted. A sharp contact separates the rooted clay from the base of the overlying silt or sand. At the top of this is a silt with muddy mottles.

CV5--Mottled Muddy Sand-- (Fig. 50E)-- The base of this unit is marked by a bed of probable rip-up clasts. Above this dark-gray mottled beds are interbedded with ripple laminated very fine sands (Fig. 51B, 51C). The rippled sands indicate periods of bedload transport and deposition. The muds with their sandy mottles probably are the partial homogenization product of mixing separate sand and mud layers due to bioturbation.

Distribution of Units

Backswamp

The dark blue clay (FB1), the deepest unit encountered, has a blanket-like distribution throughout the study area (Fig. 22, 30). In the backswamp, it is overlain by a massive appearing sandy, clayey silt (FB2) (Fig. 22A) which is thickest in the western part of the backswamp and thins eastward towards the paleo-channel. Above this the mudball conglomerate (FB3) forms a thin bed in the lowest part of the flood basin (Fig. 22A) which pinches out towards the east.

Rooted clay (FB4) which is the thickest and most surficial of the backswamp units grades laterally into burrowed silty clay (FB5) near the paleochannel (Fig. 22A). It also interfingers with coarser grained levee and splay units (FB6, FB7 and FB9) near the paleo-channel (Fig. 22, 30) and is vertically gradational with a thin dark brown pelletal mud (FB8).

Levee

Along levee profile A, the silty clay (FB5) thickens and rises in elevation towards the paleo-channel (Fig. 22A). Near the paleo-cutbank it is overlain in succession by a pelletal silt (FB7) and rhythmically layered sand, silt and clay (FB9) which distally interfinger with rooted clay (FB4) of the backswamp. Both units are thickest at the paleo-cutbank and thin and pinch out westward.

When the concave bench formed proximal levee deposits adjacent to the paleochannel were removed by cutbank erosion (Fig. 22A, Profile A). Profile B includes proximal levee deposits that were not modified by concave bench formation (Fig. 22B, Fig. 54). Here the dark blue clay (FB1) and the burrowed silty clay (FB5) were not intercepted because the cores weren't long enough (Fig. 54). The deepest unit intercepted was a rhythmically layered silt (FB6). Proximal to the paleo-cutbank, this silt (FB6) is overlain by pelletal silt (FB7). Distal to the paleo-cutbank, the two units (FB6 and FB7) are lateral equivalents. The pelletal silt (FB7) is abruply overlain by the thin unit of dark-brown pelletal mud (FB8) which grades upward into an interfingering tongue of rooted clay (FB4). The rooted clay (FB4) is overlain by rhythmically layered sand, silt and mud (FB9) which is thickest next to the paleo-cutbank, thinning distally.

Splay Lobe

The same sequence of units mapped along levee profile B (Fig. 54) is present beneath the splay lobes (Fig. 30). However, here the coarser-grained units (FB6, FB7, FB9) are thicker next to the

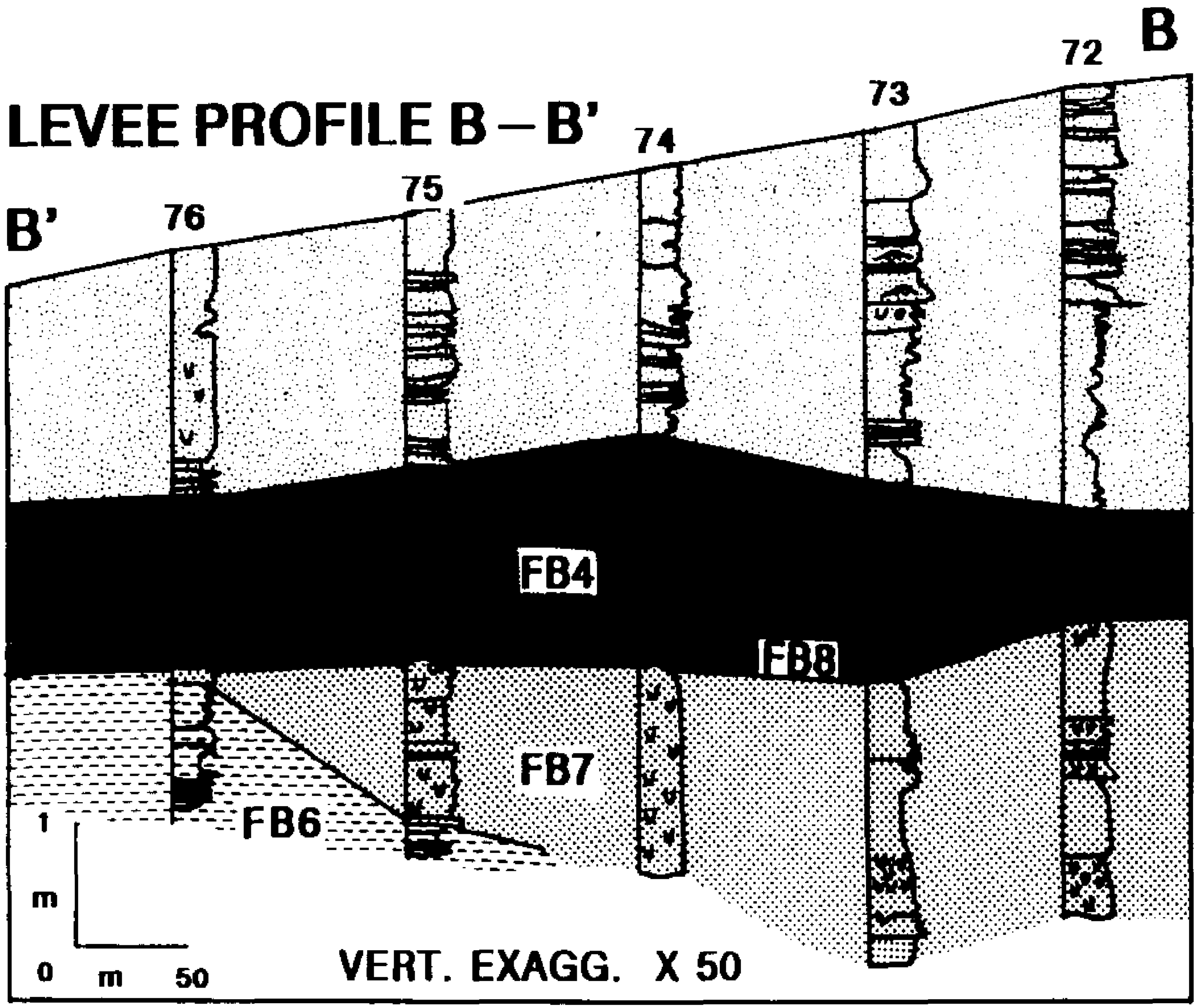


Fig. 54- An expansion of Levee Profile B. The location of this profile is shown in Figure 6. (Key is shown on Figure 22).

paleo-cutbank and extend much farther out into the flood basin than they do along the levee profiles.

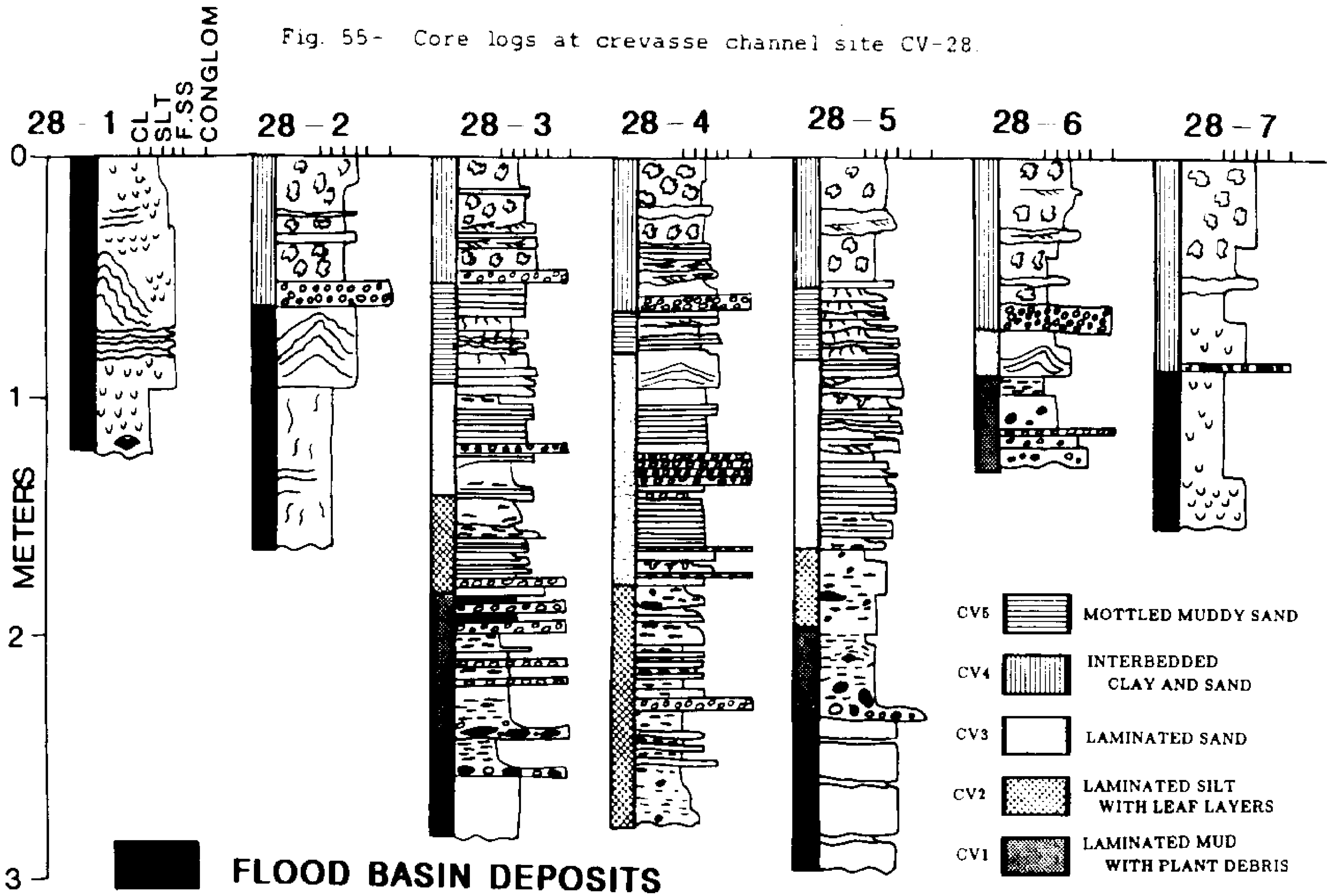
A fine-grained, clay-rich unit correlative with FB1 or FB5 was intercepted at the base of the sequence next to the oxbow lake (Fig. 30G). Distally, this unit presumably grades laterally into rooted clay (FB4) more typical of the backswamp. It is overlain by rhythmically layered silt (FB6) which grades upward into pelletal silt (FB7). Units FB6 and FB7 together form a sediment package that thins-out towards the flood basin (Fig. 30H).

Pelletal silt (FB7) is sharply overlain by dark-brown pelletal mud (FB8) which grades upward into rooted clay (FB4). Distal to the paleo-cutbank, rooted clay (FB4) thickens and replaces the silt units (FB6 and FB7) laterally. Proximal to the paleo-cutbank the rooted clay (FB4) interfingers with the coarser units representing levee and splay progradation (FB6, FB7, FB9). The surficial, rhythmically bedded sand and silt and clay (FB9) also thins and fines towards the flood basin.

Crevasse Channel Fill

Five units were observed in a cross-section through crevasse channel fill (Fig. 47, 55). The lowest unit, the laminated mud with plant debris (CV1), drapes the channel floor and sharply overlies levee and splay deposits. The four units above this (CV2, CV3, CV4 and CV5) probably interfinger or grade into the laminated mud with plant debris (CV1) along the sides of the channel. The stratigraphic section from the middle of the channel fill at site CV-28 (Fig. 55) shows that the basal laminated mud with plant debris (CV1) is overlain in succession by laminated silt (CV2), laminated sand (CV3), inter-

Fig. 55- Core logs at crevasse channel site CV-28.



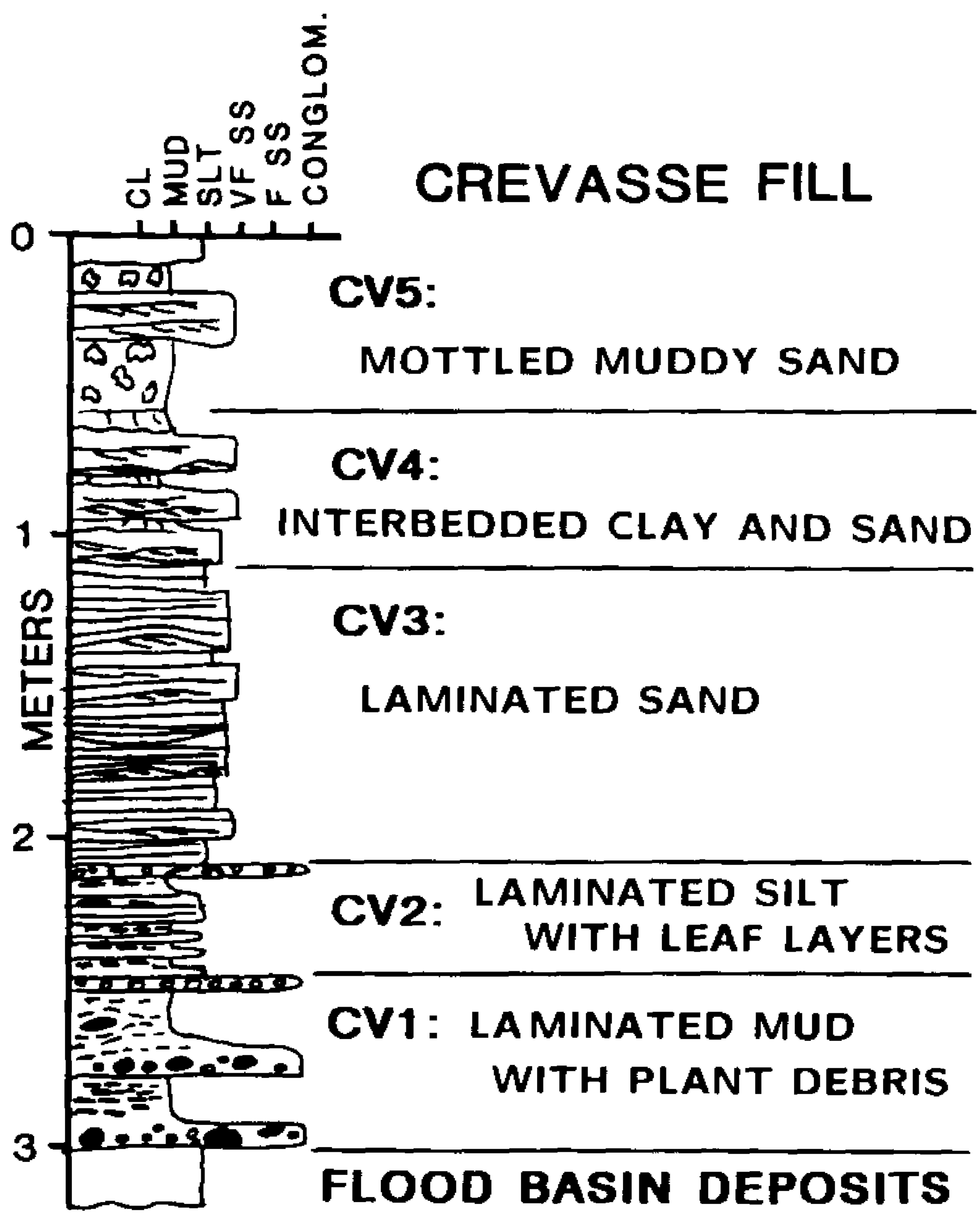


Fig. 56- Stratigraphic sequence of crevasse channel fill at site CV-78.

bedded sand and clay (CV4) and mottled muddy sand (CV5) (Fig. 56).

INTERPRETATION OF SEQUENCES

Backswamp

Pre-Avulsion Sequence-- The dark-blue clay with leaf layers (FB1) at the base of the backswamp sequence (Fig. 45) is aerially extensive with a blanket-like distribution beneath all levee and splay units. It was probably deposited in lacustrine or pond-like conditions in a swamp that predated the establishment of the meander belt at its present location in the flood plain.

The dark color of the clay, presence of pyrite and absence of pervasive burrowing suggest reducing conditions. The excellent stratification, absence of rooting, absence of pelletal fabric, and preservation of organic debris indicate deposition subaqueously. The alternating clay and leaf layers indicate seasonal deposition, a periodic distal source for terrigenous clastics, and standing water conditions for suspension sedimentation. Wispy silt laminae disturbed by nematodes (?) may indicate periodic aerobic conditions in the bottom waters. This unit resembles the lacustrine or poorly-drained swamp environment of Coleman (1966) and Krinitzsky and Smith (1969).

The overlying FB2, a relatively massive sandy clayey silt, resembles the pelletal silt of surficial levee deposits distal to the paleo-channel and splay lobe deposits distal to crevasses. Pelletal silt originates as thin rhythmic layers deposited distally from the sources of sheet floods which are burrowed into a pelletal fabric.

The massive sandy clayey silt (FB2) thickens to the west and thins to the east where it pinches out (Fig. 22A). It has no connection with the present meander belt and probably originated as a splay lobe building out from an ancient meander belt to the west which locally aggraded the lake bottom so that subaerial conditions prevailed. The absence of well preserved primary stratification also indicates a subaerial origin.

Massive-appearing burrowed clayey sands and silts similar to FB2 have been observed in cores through lake-filling deltas in the Atchafalaya Basin (Robert Tye, personal communication). These beds were present at the top of coarsening upward sequences which he interpreted as vegetated aggradational levee deposits.

Avulsion Sequence-- The establishment of the meander belt at its present location in the flood plain is recognized in the backswamp section as the lithologic change from sandy clayey silt (FB2) to mudball conglomerate (FB3) (Fig. 45). The mudball conglomerate (FB3) was deposited as probable multiple beds of rip-up clasts related to a series of major floods that moved through the flood basin either concurrently with or prior to the avulsion.

Progradational Sequence-- Once the meander belt was established the rooted clay unit (FB4) was deposited from suspension as a progradational unit from distal sheet flood waters which tended to fill or partially fill the flood basin during flood season. Pervasive root mottling and the presence of carbonate coated leaf fronds in the lower part of unit indicate that a vegetation cover of trees, possibly a Cypress swamp, became established once the meander belt began to form. Periodic incursions of silt-sized sediment indicates that large scale floods sometimes entered the basins. Pervasive burrows of the *Muensteria* type in slightly coarser sediment between the large root mottles indicate that sub-aerial conditions prevailed during part of the year. The slight coarsening of the unit from pelletal clay to pelletal mud upsection indicates the progressive progradation of relatively coarser sediment over time from the meander belt.

Flood Events-- Throughout the rooted clay unit (FB4) stratification of any sort is rare. However the presence of carbonate coated leaf layers, rooted horizons, banding and remnants of burrowed laminates breaks the montonony of the clay and indicate a periodicity in sedimentation associated with very distal sheet flood sedimentation or intervals of high standing water in the flood basin. Pelletal mud with remnants of primary laminations is present at the top of the sequence and grades laterally into coarser rhythmites of the natural levee.

Primary, replaced or coated organic material acts to delimit individual flood events. Rooted horizons imply that a stable rooted substrate was inundated by a flood and that suspension sedimentation buried the rooted zone. Rooted horizens can be seasonal, developing at the end of a flood season on newly deposited mud. Discontinuous laminations of primary organic debris probably indicate low-lying swale areas where water remained ponded, allowing anaerobic conditions to persist.

Leaf horizens, even if present as carbonate casts, indicate a ground cover of leaves at the end of a flood cycle. Leaf horizens could represent an organic drape stranded by falling water at the end of a flood cycle or the seasonal accummulation of organic debris under subaerial conditions.

Sequence Summary-- The sequence of four units preserved beneath the backswamp (Fig. 45) indicates several periods of deposition from the bottom to top. These are: 1) a period of standing water deposition of clay and leaf debris (FB1) in a poorly-drained swamp or shallow lake environment; 2) incursions of distal splay sheet flood or possibly lake delta sands and silts (FB2) into the lake, 3) major flood activity causing erosion and redeposition of previously deposited clays as the mudball conglomerate bed (FB3); 4) deposition of rooted clays (FB4) as distal sheet flood deposits associated with a prograding wedge of overbank sediment during establishment of the meander belt at its present position in the flood plain.

Levee and Splay Lobe

Pre-Avulsion Sequence-- The establishment of the meander belt at its present location in the flood plain is recorded in this sequence by the lithologic change from dark-blue clay (FB1) to the overlying massive to burrowed clayey silt (FB5) (Fig. 46).

The basal clay (FB1) was presumably deposited under lacustrine conditions. The overlying clayey silt (FB5) is an incipient fine-grained distal levee deposit which was prograding westward from a channel to the east. The absence of primary stratification, and the presence of root burrowing and pelletal fabric indicate that it is primarily a subaerial deposit which was post-depositionally modifed by trees, arthropods (?) and/or earthworms (?). The mud-sized sediment with its pelletal fabric indicates very distal sheet flood sedimentation with the primary stratification probably originating as clay-rich laminates in the backswamp-levee transition zone. Sedimentation conditions probably consisted of very low velocity flows moving around trees and suspension sedimentation.

Progradational Sequences-- The levee and splay lobe sequence is divisible into two periods of progradation (Fig. 46) each of which is about 3-4 meters thick. Intervals of clay deposition under lacustrine or backswamp conditions precede each phase of progradation.

The lower progradational sequence consists of four mappable units: dark blue clay (FB1) is replaced in succession up-section by massive to pelletal silty clay (FB5), rhythmically layered silt (FB6) and pelletal silt (FB7). The section coarsens upward between FB1 and FB6 because grain size increases and thicker, discrete, coarser grained layers are added upsection at the expense of clay or mud layers. Between the rhymically layered silt of FB6 and the pelletal silt of FB7, the thickness of both coarse and fine layers decreases and silt overall predominates, although thoroughly burrowed.

Rhythmically layered silt (FB6) with its well preserved primary stratification closely resembles proximal to medial levee and splay deposits because it primarily consists of silty rhythmites with minor sandy rhythmites and pelletal silt. It does however include some subtle differences in stratification which indicate that it was deposited subaqueously. The unit is best developed in the subsurface distal to the paleo-channel, in lower lying parts of the flood basin where sub-aqueous conditions could easily develop during flood season.

Evidence supporting subaqueous deposition includes unusually well-preserved primary stratification in the coarser layers, sharp contacts between coarse and fine layers, absence of rooted horizons, and little bioturbation. As an example, silt/clay laminates (or very thinly layered silty rhythmites) with beaded appearing clay layers are a common facies here.

Each silt/clay couplet was deposited from suspension when a sheet flood decelerated upon entering an ephemeral shallow body of standing water. The clay layer was slightly disrupted into the beaded appearance by horizontal burrowers (earthworms and/or arthopods) that probably only had a few hours before the next sheet flood entered the lake. It is probable that multiple sheet floods entered the lake during a single flood season because the laminations occur in sets (10 cm) which lack internal rooted zones and the pelletal fabric so common on the subaerial levee and splay. If the beaded appearance of the mud layers is a loading phenomenon due to soft sediment deformation this is further evidence that multiple sheet floods were active during a single season and that the laminates were deposited subaqueously.

Thick cross-bedded unburrowed sands lacking internal discontinuities appear to be deposited during sustained flows (Fig. 38F). These are overlain by crossbedded sands with burrowed, discontinuous, muddy drapes indicating multiple successive periods of bedload transport, current cessation, suspension sedimentation, and a brief interval of burrowing activity. These deposits could easily have accummulated in a broad channel-like trough or topographic low in distal parts of the levee.

The rhythmically layered silts (FB6) are replaced upsection by pelletal silt (FB7). Rare remnant layering and traces of cross-stratification indicate that the primary stratification consisted of very thin silty rhythmites or interlaminated silt and mud which was subsequently burrowed into pelletal silt under subaerial conditions. Pelletal silt is common on surficial splay lobes and distal levee deposits and this unit is interpreted as such.

The transition from well-stratified (FB6) to pelletal silt (FB7) indicates a change from sub-aqueous to more subaerial deposition as the levee aggrades over time relative to flood height. Higher levees are flooded less frequently because overtopping events become rarer and deposition thinner. Thin layers of sediment are easily disrupted by bioturbation into pelletal silt. Thus, the transition from FB6 to FB7 indicates the beginning of an abandonment phase in levee or splay progradation.

The pelletal silt (FB7) is abruptly overlain by a thick interval of pelletal mud (FB8) and rooted clay (FB4) indicating an end to the first phase of levee and splay progradation. The sharp lithologic change from pelletal silt to mud probably means that the meander loop supplying sheet floods was suddenly cut-off as a neck cut-off and no longer supplied coarser sediment to the local levee and splays.

The paleo-channel, a principal source of sheet floods, meanders freely within the meander belt. As successive meanders are translated downstream during this migration process, the source of the sheet flood becomes more distal or more proximal at a given site in the flood plain. If the source of the sheet flood is distal, clay is locally deposited. If a neck cut-off occurs, then the meander loop which served as a local sheet flood source is abruptly lost and clay is deposited from flood waters with a distal source. A more gradual abandonment of a meander loop such as a chute cut-off would probably be recorded as a fining upward sequence into rooted clay. Thus sheet sands and silts (FB6, FB7, FB9) are interstratified with backswamp clays in flood basins next to meander belts because of the migratory nature of the meander loops within the meander belt.

The pelletal mud of FB8 with its remnants of interlaminated silt and mud, fine grain size and thinness of the laminations suggests sheet flood sedimentation from a distal source under low-lying backswamp conditions. The dark-brown color of the finer layers suggests that organic debris was being deposited with the mud and possibly reducing conditions. The pervasive burrowing indicates subaerial, but damp conditions. An alternative explanation is that the dark brown mud represents an A-horizon of a soil, which was was not inundated for a long time.

The thick sequence of rooted clay (FB4) lacking well-defined stratification, with its local pelletal fabric, pervasive large-scale root-mottling and fine-grained nature indicates suspension deposition from distal sheet floods subaerially on vegetated terrain.

In the upper progradational sequence, the rooted clays (FB4) are overlain by a single unit of rhythmically layered sands, silts and clays (FB9) which distally grades into pelletal silt as the layers decrease in thickness. Obviously this entire unit was deposited during a second period of levee and splay progradation that was effected by the gradual migration of the False River meander loop towards the study site before the neck cut-off occurred. An in depth discussion of the origin of specific bedding types within this unit is discussed elsewhere in this document. Smaller-scale sedimentary cycles in this unit are discussed below.

According to Fisk's (1944) interpretation of the geomorphic evolution of the study area (Fig. 10), the entire package of sediment that was deposited in the flood basin after the meander belt was established is related to the gradual migration of the False River meander loop towards the study area for 3000 years until a neck cutoff formed the oxbow lake. Such a gradual and continuous migration of a meander loop toward a sampling site should result in a single progradational sequence that mainly coarsens upward. The stratigraphy observed does not support Fisk's interpretation of the geomorphology. Rather, after establishment of the meander belt, there were two successive periods of progradation, each of which ended with a neck cut-off. Geomorphic evidence within the meander belt that would support a second earlier phase of loop migration and neck cut-off was obviously destroyed by the second phase of meander loop migration. The implication is that meander loop migration in the unrestrained Mississippi River is twice as rapid as Fisk believed.

Vertical Variation in a Progradational Sequence-- Vertical variation in the rhythmically layered sand, silt and clay unit (FB9) typically displays an orderly succession of bedding and/or grain size changes. Coarsening upward phases in FB9 are present as 1) a progressive increase in grain size up-section in the coarser layers (Fig. 57A), 2) an increase in sand or silt bed thickness up-section (Fig. 57B), 3) a decrease in clay or mud thickness up-section (Fig. 57C), or 4) a change in bedding type from pelletal silt to silty rhythmites to sandy rhythmites up-section (Fig. 57D).

Fining upward sequences are identified as 1) a gradual decrease in grain size upsection (Fig. 57E), 2) a decrease in silt or sand bed thickness up-section (Fig. 57F), 3) an increase in clay or mud bed thickness upsection (Fig. 57G), or 4) a change from thick pelletal silt or sand beds into rhythmic bedding (Fig. 57H).

Several types of sequences are present in surficial levee and

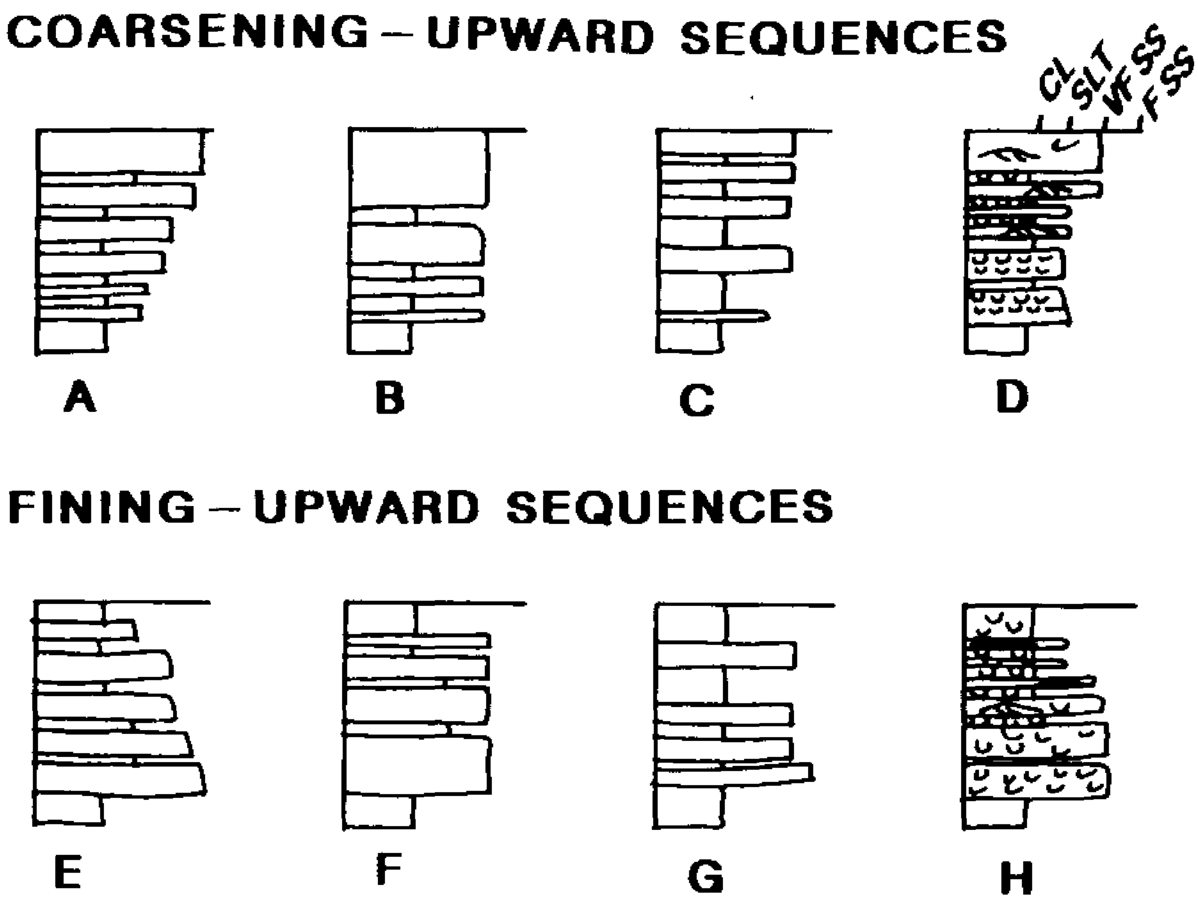


Fig. 57- Fining and coarsening upward sequences in levee and splay lobe deposits.

splay lobe deposits (FB9) at a number of different scales: 1) a 1-4 m thick sequence encompassing the total thickness of FB9 which represents the progradation of the levee or splay lobe due to migration of the meander loop towards the study site over time, 2) smaller-scale sequences (dm thick) that reflect local topography and climatic variations over time, and 3) individual flood events (mm-cm thick) that reflect the magnitude of floods.

1-4 M Thick Sequences-- Although FB9 is highly variable in vertical sequence, it commonly coarsens upward from its base over a thickness of about 1 m and then fines upward slightly (Fig. 54, core 74). As an example, proximal levee (Fig. 49B) and splay lobe (Fig. 49A) sequences coarsen upward as rooted clay (FB4) is overlain in succession by silty rhythmites and then coarser and more thickly layered sandy rhythmites. Above this, the sequence fines slightly into pelletal silt, or finer grained and more thinly interlayered rhythmites depending on distance from the source of the sheet flood and the intensity of the flood. The distal levee sequence (Fig. 49C) exhibits the same overall trends and a thin basal zone of silty rhythmites is overlain by a thick interval (2 m) of pelletal silt.

The sequence pattern described above is not present everywhere. Locally FB9 may initially fine upward (Core 86, Appendix D, Profile A) or consist of a complex stack of smaller-scale coarsening or fining-upward sequences (Appendix D, Profile A, Core 84)). Odd occurrences of structureless muddy sediment which do not seem to fit into any orderly progression of bedding or grain size in levee deposits may be infillings of very large root burrows (in cores 85 and 86, Appendix D, Profile A).

A sequence solely interpreted as representing splay lobe progradation is identifiable in distal parts of the splay because here FB9 is very thin (1 m), underlies definitive splay topography, and is present in part of the flood basin that geomorphically is not a levee (Fig. 49D, 49E). The sharp lithologic change from rooted clays below (FB4) to the overlying silt and sand-rich unit (FB9) and the concentration of mudballs above this contact probably are synchronous with the original crevassing of the natural levee (Fig. 49D, 49E).

In fining-upward splay lobe sequences (Fig. 49D), thicker beds of burrowed sandy laminates are succeeded upsection by more thinly interlayered and finer grained rhythmites and burrowed clay/silt laminates. Above this the section fines into more massive appearing pelletal silt which originally consisted of alternating laminations of silt and mud. Thus the thickness of the individual layers thins up-section. Traces of ripple laminations which indicate a flow direction towards the flood basin are present.

When the thickest, coarsest grained sand beds are present near the base of any levee or splay lobe sequence, this indicates that sheet floods with the highest competence and greatest transporting power occurred early on during the progradation of FB9. The fining-upward part of the section above this indicates that as the region built up over time the frequency and intensity of flooding diminished. The initial strong flow conditions was a consequence of relatively low unconfining levees that allowed frequent levee overtopping events and sustained flows. This allowed rapid progradation of the levee. High, well-developed levees that are a consequence of a long period of levee progradation, acted as a confining wall to flood waters and ultimately caused a decrease in the frequency of levee overtopping events. The result is an apparent abandonment phase in the stratigraphic sequence indicated by the fining upward part of the sequence as bedding thins to laminates and pelletal fabrics dominate.

In coarsening-upward distal splay lobe sections (Fig. 49E) silty rhythmites are succeeded up-section by sandy rhythmites with well-developed very small-scale cross-stratification (Fig. 51A) and then pelletal silt or sand (Fig. 49A). Sequences like this could indicate progradation of very thin bar-like forms into the flood basin on distal lobes. Since the transition from sandy rhythmites into pelletal silt or sand probably correlates with a thinning of layering upsection, it is also possible to interpret this transition as a slight abandonment phase in splay lobe development.

Smaller-Scale Sequences-- Smaller-scale sequences on the order of decimeters and centimeters are also present (Fig. 49, 58). Because lateral variability is the rule rather than the exception the variation is probable due to local, subtle changes in topography and changes in flood climate over time. As an example of these small-scale sequences, well-stratified distal levee deposits (cores 87 and 88, Appendix D, Profile A) are easily differentiated into individual sheet flood events as well as several orders of small-scale progradational events (Fig. 58).

Small-scale fining upward sequences may indicate a gradual decrease in the magnitude of sheet floods over that period of time or a progressive infilling (progradation) of a topographic low over time. Alternatively, small-scale coarsening upward sequences may be interpreted as a gradual increase in the magnitude of sheet floods

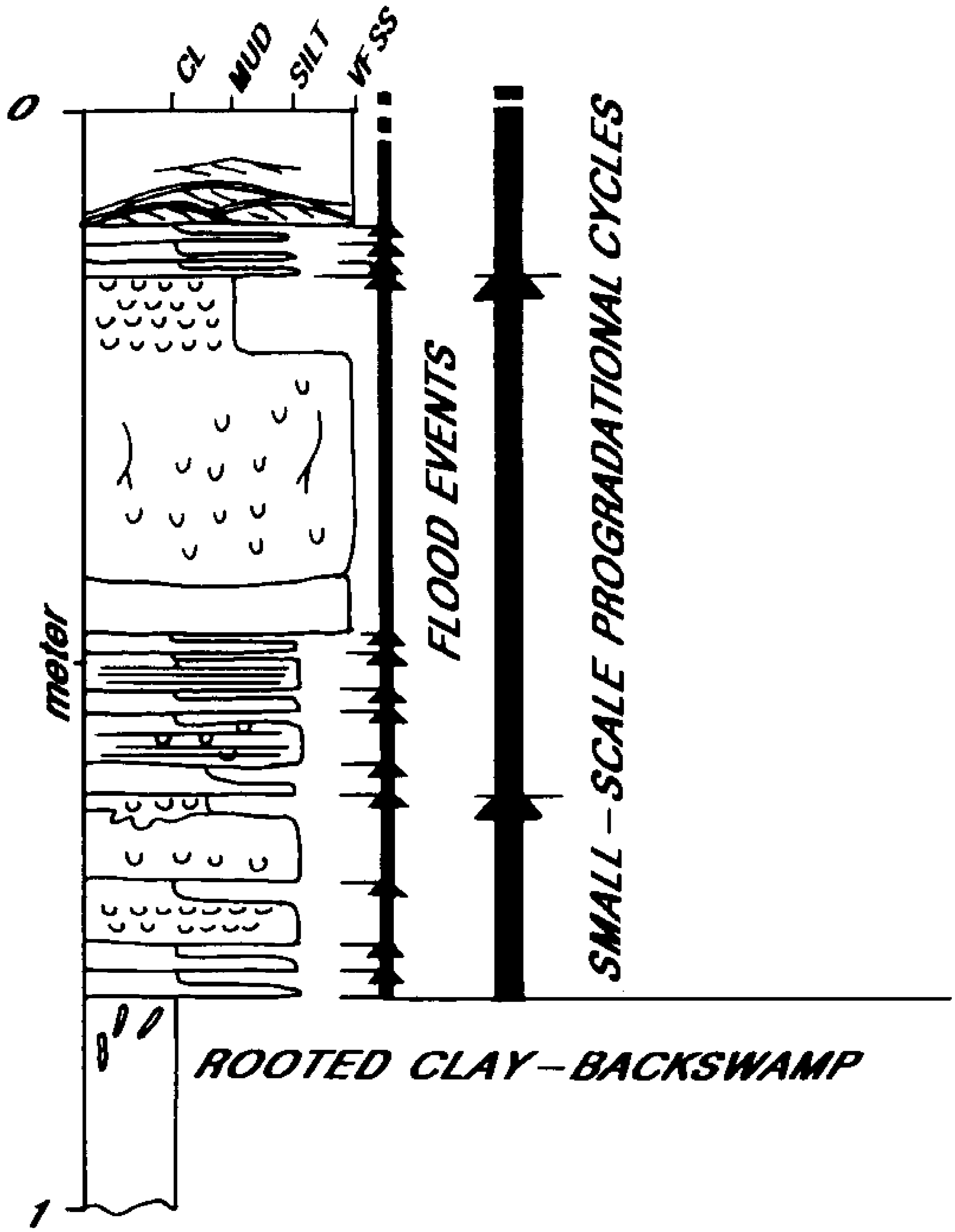


Fig. 58- Small-scale progradational events in levee and splay lobe deposits.

over time or a gradual progradation of a sand sheet into the vicinity. It was not possible to calculate the recurrence interval of large floods which would allow the deposition of a thick sandy bed because the organic material necessary for radiocarbon dating was not preserved in the sequence. However, based on the date that the meander belt was established (circa 3000 years B.P.) and the maximum thickness of the levee/splay sequence (10 m) it is reasonable to assume that a small-scale sequence about 30 cm thick was deposited during a 100 year interval.

Channelized flows in crevasses and over topographically low areas between crevasses would be the most competent and could transport the coarsest sediment. As flow waned near the end of a flood, the coarsest sediment would be deposited at the base of these low-relief channels. Topographically low areas would aggrade during successive floods and ultimately lose the ability to channelize relatively higher velocity flows. Progressively finer or more thinly layered deposits would be deposited as the shallow channel filled in. Flows of lower intensity and lower competence that originated in the broad shallow channels would travel over topographically high areas between channels. Thinner beds of finer grained sediment would be deposited here at the same time that coarser and thicker sand beds were being emplaced in low lying areas.

Differentiating Levee and Splay Lobe Deposits -- Levee and splay lobe deposits are virtually indistinguishable from each other because they exhibit the same sequence of lithologic units and the same types of stratification such as rhythmically emplaced beds of sand, silt and clay and pelletal (burrowed) fabrics.

Levee deposits are different from splay lobe deposits because they include, more commonly, thicker, discrete beds of mud or clay. These fine-grained beds are thinner and less common in distal splay lobes. In addition to this, sandy rhythmites are present in levee deposits only along a narrow band next to the paleochannel. However, sandy rhythmites of surficial splay lobe deposits extend about 2.5 times farther out into the flood basin than the sandy rhythmites of levee deposits do (Fig. 42).

In order to differentiate levee from splay lobe deposits, the geologist must have some knowledge of the geometry of the deposits. Splay lobe deposits should be associated with crevasse channel-fill sequences. Such channels would not be present in levee deposits. In addition to this, FB9 is thicker and more areally extensive in splays.

Crevasse Channel Fill Sequence

CV1-- After the crevasse channel was excavated into the levee (FB9) and during major flow activity a coarse lag accummulated on the channel floor forming the base of CV1 (Fig. 56). Tree branches were stranded in the excavated channel. Laminated mud and clay settled in spaces between the organic debris during periods that the channel was inactive and probably blocked at its head. Intercalated laminations of macerated plant debris represent seasonal deposition on an annual scale in stagnant waters.

Beds of rip-up clasts record sudden incursions of flood waters into the reoccupied channel. The laminated layers between the mudball beds are interpreted as periods of suspension sedimentation in stagnant water between floods. The silt layers at the top of the unit indicate that current movement is strong enough to transport and deposit silt. Sediment laden waters are entering the channel perhaps from runoff.

CV2-- Sporadic mudball horizons indicate periodic renewed flow strong enough to erode, transport and redeposit clay (Fig. 56). Other evidence of periodic flow is preserved as leaf laminations and burrowed contacts marking the end of sedimentation cycles. Sporadic ripple laminated beds are present indicating that currents were occasionally strong enough to support bedload transport.

Each normally graded lamination is comparable to a cloud of sediment laden water entering the crevasse, decelerating, and depositing silt. This water is obviously moving fast enough to transport silt in suspension. However, at the channel floor current activity is too slow to cause bedload transport and the reorganization of the coarse silt into small ripple forms. Multiple clouds of turbid water entering the crevasse during a single season of 'sustained' flow are responsible for the graded laminations being grouped into sets. Leaf layers or burrowed horizons separate sets of parallel laminations or ripple laminations. These horizons represent interludes of non-sediment deposition and very slowly moving waters between flood cycles.

CV3-- The presence of ripple laminations, coarser sediment (sand), and the absence of organic debris indicate that periods of flow were more sustained and slightly stronger during deposition of this unit. The absence of mudball horizons indicates that the flow was however sporadically less violent. Sets of graded laminations that decrease in thickness upsection indicate that multiple pulses of sediment laden water which diminished in magnitude over time entered the crevasse over a single flood season.

CV4-- Each rhythmite represents a period of sustained flow with bedload transport followed by period of stagnant water deposition and the establishment of root systems on the channel bottom (Fig. 56).

CV5-- The mudball bed at the base of this unit represents a major incursion of flood waters into the channel (Fig. 56). The mottled sands result from biogenic mixing of mud and sand layers. Much of this mixing is probably caused by plant roots and large animals moving through the soft, mushy substrate. The thin localized layers of ripple-laminated sands are caused by reworking due to periodic flow in the channel. After major runoff events or very high water levels in the oxbow lake, the local water table becomes elevated and causes flowage from the crevasse into the backswamp.

Summary of Major Events in Flood Basin Evolution

The sequence of events recorded by the flood basin stratigraphy is related to the establishment of the meander belt at its present location in the flood plain. The distribution of the units and their lithologic characteristics are summarized as follows.

Pre-Avulsion Stage (Fig. 59A)-- Before the meander belt was established at its present location in the flood plain, a flood basin existed in the study area and clay with plant layers (FB1) was deposited under lacustrine conditions (Fig. 60A). A clayey sandy silt (FB2) prograded as a distal splay lobe from a meander belt to the west into the low-lying flood basin (Fig. 60B).

Avulsion Stage (Fig. 59B)-- A series of relatively dramatic flood events ripped up pre-existing clays in the flood basin and redeposited

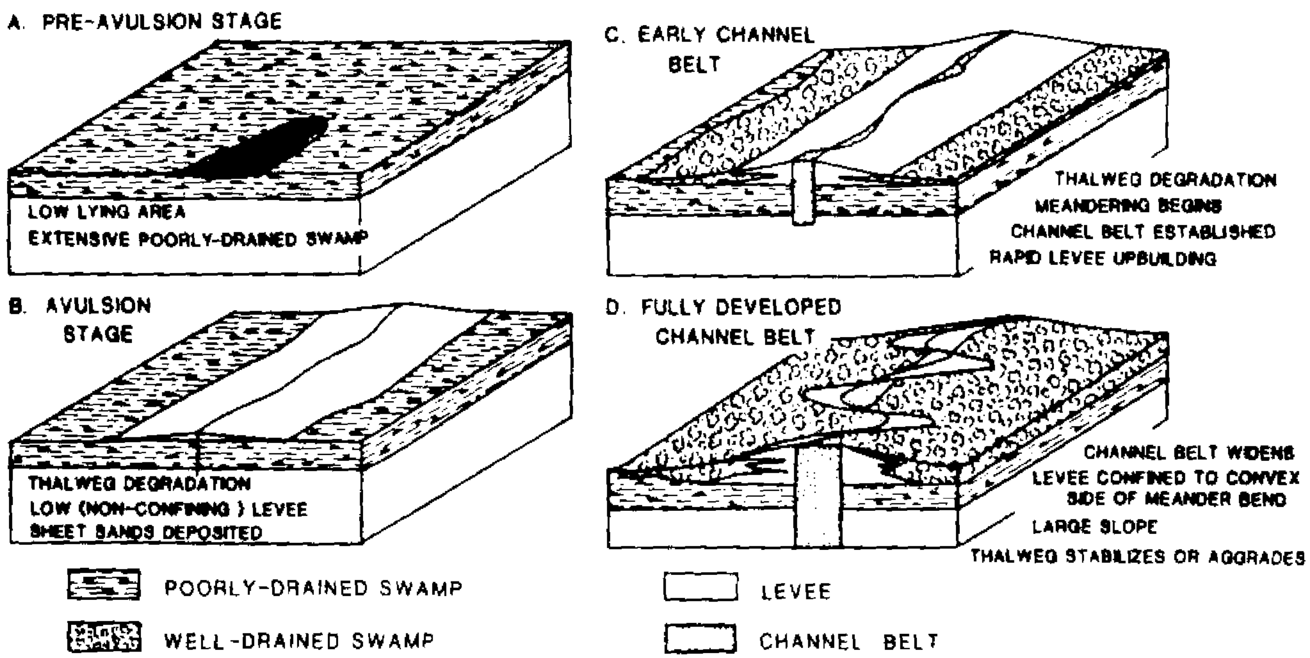


Fig. 59- Evolution of the meander belt.

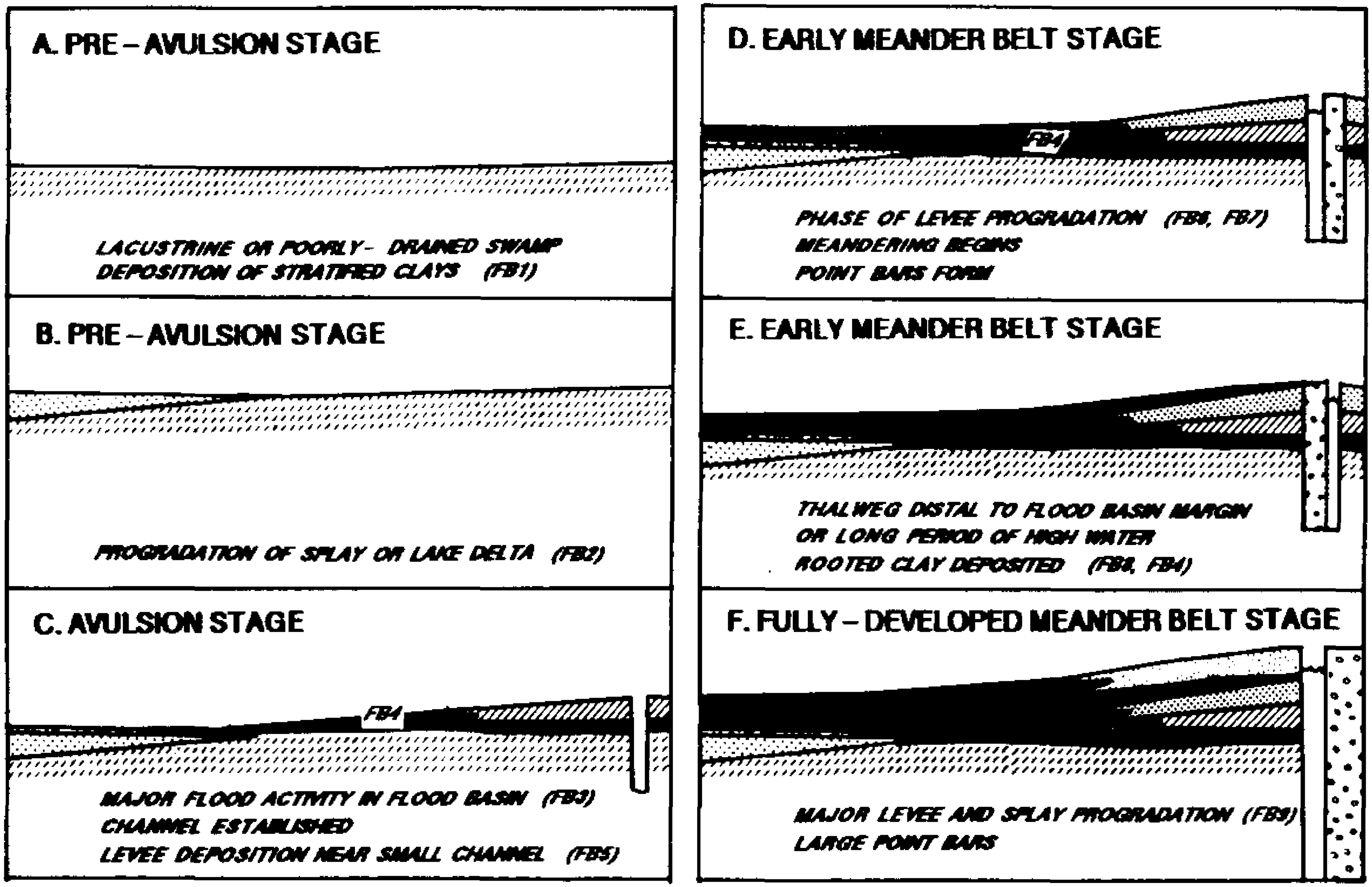


Fig. 60- Flood basin evolution.

them as a mudball conglomerate during the avulsion stage (Fig. 60C).

A channel came to exist here, possibly due to the extension of a crevasse channel from the distal, then-active meander belt (Fig. 60B). During large floods in this distal meander belt, the extended crevasse captured a significant volume of the main stream flow. The crevasse became incised into pre-existing flood basin deposits. Early overtopping events resulted in the deposition of burrowed and rooted clayey silt (FB5) along the channel (Fig. 60C) and a low and relatively unconfining levee developed.

Avulsions probably take place over a period of several hundred years. As an example, the Atchafalaya River, into which the present Mississippi would avulse if it were not confined by artificial structures has been in existance for several hundred years as a subsidiary distributary for the Mississippi River during flood stage.

Early Meander Belt Stage (Fig. 59C)-- As the crevasse captured a larger volume of the main stream flow, its thalweg degraded while the levee aggraded. Incipient meandering began as small twists similar in scale and configuration to the the trace of the present Atchafalaya River channel. The newly forming meander belt was initially narrower and shallower than the present meander belt. Coarser material was transported by the stream and point bars began to form.

The levee built rapidly upward as rhythmically bedded and burrowed sands, silts and clays (FB6 and FB7) prograded as a wedge from the edge of the newly developing meander belt into the flood basin (Fig. 60D). The coarsening-upward sequence was probably caused by the migration of a meander bend (potential sheet flood source) towards the sampling site. Rooted clay (FB4) accumulated contemporaneously in the backswamp (Fig. 60D).

The meander loop supplying sheet sands and silts was suddenly cut-off so that clays (FB8 and FB4) which were subsequently rooted were deposited proximal to the paleo-channel (Fig. 60E) from standing water in an intermittantly filled flood basin.

Fully Developed Meander Belt Stage (Fig. 59D)-- Rhythmically bedded sands, silts and clays of FB9 prograded from the meander belt margin into the flood basin during a second progradational event (Fig. 60F) caused by a meander loop migrating towards the study site over time. As the meander belt grew in width due to cutbank erosion and the levee became higher and more confining with respect to main stream flow, deposition on the levee became restricted to the concave side of meander bends. Sheet sands and silts were not being deposited on the convex side of meander bends: this is the site of active point bar style deposition. Thus sheet sands and silts of levee and splay lobe deposits are preferentially preserved in the flood basin along the edge of the meander belt.

Formation of the crevasses probably occurred prior to the neck cut-off in 1700 A.D. but post-dated the deposition of the lower 2/3rds of FB9. The crevasses themselves were overtopped and splay lobes built up progradationally by sheet flood sedimentation.

Three main episodes of sedimentation resulted in the infilling of the crevasse channel (Fig. 56). Initially, the channel was excavated by major flood currents which resulted in the deposition of a lag deposit at the base of the sequence. After the excavation phase, the crevasse became blocked at its head and fine-grained sediment and organic material (CV1) accummulated in the channel. Next, a period of sustained current movement resulted in the deposition of laminated and ripple laminated sand and silt (CV2, CV3, CV4). Lastly, a return to quasi-stagnant conditions allowed stabilization of the substrate by plants, trapping of fines and bioturbation (CV5). Periodic flow transported and redeposited sand over the bioturbated beds.

CHAPTER 6: DISCUSSION

Even though the crevasse splays have a channel network with intervening lobe-like features and the levees are topographically planar without channels, their identical sedimentology indicates both sub-environments formed or accreted by a similar sedimentologic process, namely sheet flow sedimentation. Both levee and crevasse splay deposits consist of extremely thin sheets of thinly (cm) to minutely (mm) interlayered sand, silt and clay which are pervasively burrowed by the trace fossil, *Muensteria*. Only traces of small ripple laminations and parallel laminations are preserved as sedimentary structures. Contacts at the base of sand layers are commonly burrowed. In addition to this, not only the grain size, but the stratification in both levees and crevasse splays changes systematically with respect to increasing distance from the source of the depositing flow in a proximality trend. These results differ considerably from previous descriptions of modern and ancient levee and crevasse splay deposits and presently accepted depositional models for crevasse deposits in interdistributary bay settings.

Because levees and crevasse splays have such differing morphologies, their forms have been attribnuted to separate processes and separate depositional models have been proposed to explain their occurrence. Elliott (1974) summarized the flood generated processes responsible for overbank sedimentation in interdistributary bays of the delta plain, 1) overbank flooding, and 2) crevassing. These processes apply to overbank sedimentation in flood basins of the fluvial sector of the alluvial system also.

Overbank flooding occurs during a single flood when sediment laden waters spill over the levee as sheet flows with no breaches or crevasse channels (Coleman, 1969). This process is principally responsible for the aggradation of a flat, featureless levee and channels are not involved. The facies relationships between sand and mud layers, or alluvial architecture, of the resulting flood basin sequence shows a series of alternating thin layers of coarse and fine material (Fig. 61A). Ancient overbank deposits interpreted as natural levee in origin usually consist of alternating relatively thin (cm) layers of ripple-laminated sandstone or siltstone and mudstone.

Alternatively, during the crevassing process, flood waters are transferred to an interdistributary bay via small crevasse channels cut in the levee crest. Elliott (1974) described two distinct mechanisms for crevassing, 1) the crevasse splay and 2) the progradation basinward of a minor mouth bar-crevasse channel couplet. Both of these mechanisms cause the formation of a geomorphic entity consisting of a channel network with intervening lobe-like features.

By definition, a crevasse splay is a sudden incursion of sediment laden water into a limited area of bay (Elliott, 1974; Coleman, 1969; Arnsdorfer, 1973). The sediment is deposited in either numerous small anastomosing streams, or at the end of a long straight crevasse channel in a region of unconfined flow further down the levee slope. Thus defined, crevasse splays form sandbodies with planar erosive bases variously described as lobes, lenses, sheets or lenticular channel units.

Sheet sands interpreted as crevasse splays have been identified in many ancient alluvial deposits and their internal stratification has

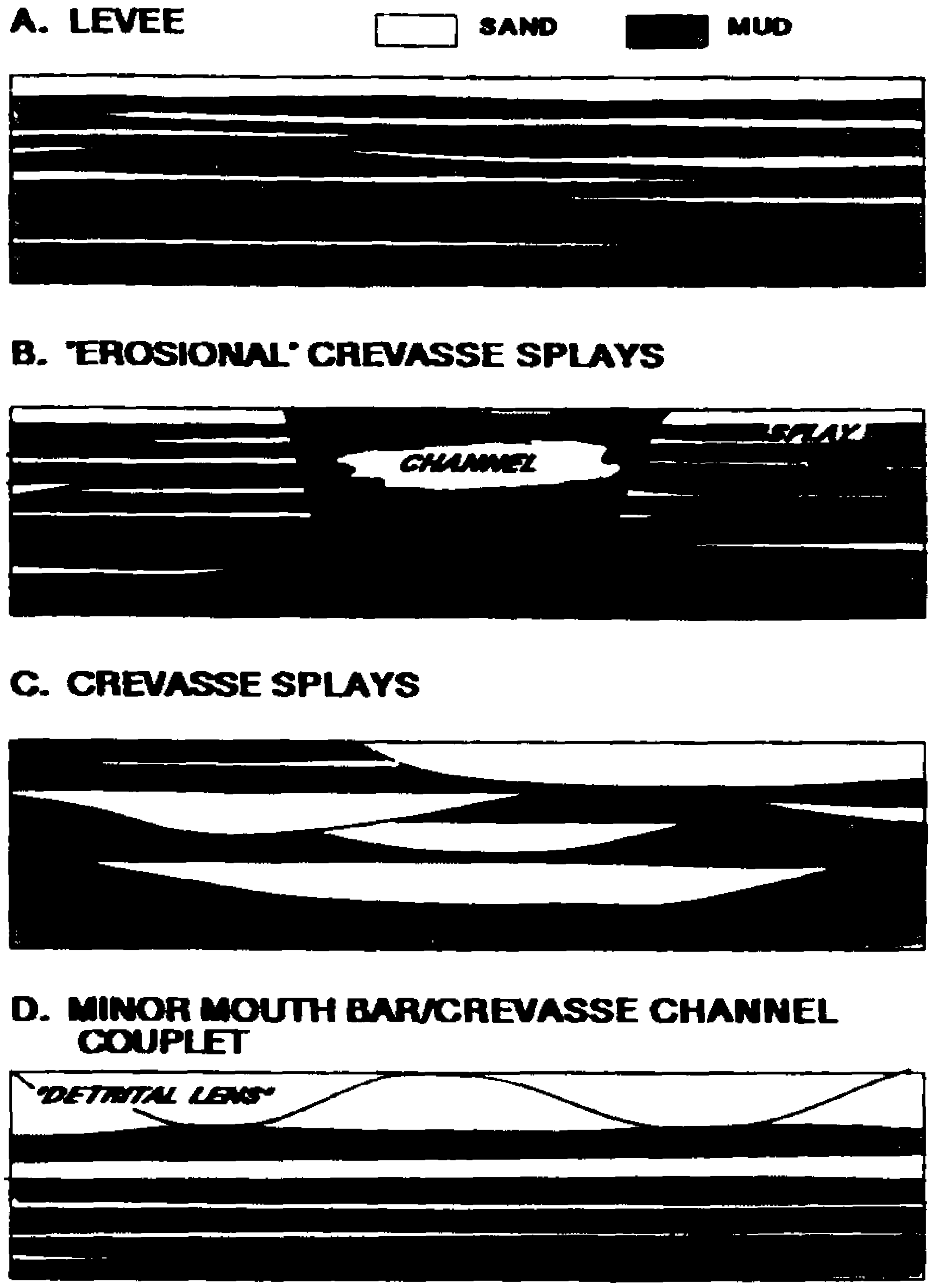


Fig. 61. Facies relations between sand and mud or 'alluvial architecture' in flood basin sequences. Cross-section is oriented at right angle to flow in crevasse channels. Schematic cross-sections C and D were developed from ideas presented in the general literature and summarized in Elliott (1974). Cross-sections A and B were based on data presented here.

been described (i.e. Stear, 1983; Johansen, 1983; Bridge and Gordon, 1985; Gordon and Bridge, 1985). These splay sandstones form relatively thick (decimeters to meters) sheets which are traceable in continuous exposures from the margin of a channel belt sandstone laterally into the overbank member where they taper out. They are typically erosionally based and fine upward internally exhibiting a variety of sedimentary structures such as upper flow regime plane beds, large-scale trough cross-stratification, climbing ripples and other structures. In contrast to the splay deposits described here burrowed sands are not observed.

Crevasse or bay-fill deposits (Coleman and Prior, 1980; Coleman, 1981) accummulate when a couplet consisting of a crevasse channel and associated minor mouth bar progrades into an interdistributary bay in the same way that a delta lobe progrades basinward. This occurs as a relatively prolonged event involving a permanent crevasse channel which extends into the central part of the bay and deposits small-scale mouth bars. As channelized flow from a crevasse enters the standing body of water, it expands, decelerates and deposits a minor mouth bar of relatively coarser grained material. The bar causes the flow to split and flow around it. The result is that an anastomosing network of channels and intervening minor mouth bars progrodes basinward over many flood cycles and ultimately forms a 'gradational coarsening upward sequence' (Elliott, 1974) as well as a 'detrital lens' at the top of the sequence (Coleman and Gagliano, 1964). The upper part of the mouth bar may be partially or completely eroded by the advancing crevasse channel as progradation continues resulting in the deposition of an erosion-based, cross-stratified channel sand facies.

Elliott (1974) presented several variations on vertical sequences genrated by these processes in interdistributary bays (Fig. 62). (For this discussion sequences that include a marine influence and wave-reworked deposits will be ignored). Simple levee progradation from sheet flood sedimentation consists of thin beds of alternating coarse and fine sediment that coarsen upsection and sedimentary structures that include flat laminations and asymmetrical ripples (Fig. 62A). Crevasse splays are recognized as unusually thick, erosive based sheets of cross-stratified sand which occur at the top of a coarsening upward sequence that otherwise resembles simple levee progradation (Fig. 62B). Another crevasse splay sequence consists of a levee progradation sequence truncated and topped by an erosive based cross-stratified lenticular channel sand of crevasse channel origin (Fig. 62C). Thus crevasse splays are preserved either as sheet-shaped lobe sands or lenticularly shaped channel sands.

There are two variations on sequences deposited by the progradation of a minor mouth bar and crevasse channel couplet that would be applicable to these fluvial deposits (ignoring wave-reworked sequences). The first is similar to a levee progradational sequence in that rhythmically layered deposits attributed to the progradation of a minor mouth bar coarsen and thicken upward. A crevasse channel deposit which consists of a thick erosion-based cross-stratified sand truncates the underlying minor mouth bar facies and is present at the top of the sequence (Fig. 62D). The alternative sequence simply consists of interdistributary bay mud which is sharply overlain by a relatively thick, sharp based cross-stratified crevasse channel sand

Fig. 62. Vertical sequences generated in overbank deposits. A through E are from Elliott, 1974.

LEVEE

A

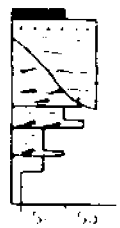
Alternating sand laden currents (overbank floods and minor crevasse splays), and deposition of fine suspended sediment
Results in levee progradation

CREVASSE SPLAY

B

Ponded sediment
Sudden incursion of sand laden current-major crevasse splay lobe
Sheet erosion
Levee progradation

C



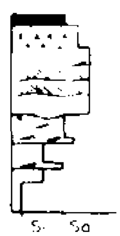
Lenticular channel units of crevasse splay origin, with unidirectional palaeocurrents
Levee progradation

MINOR MOUTH BAR-CREVASSE CHANNEL

D

Crevasse channel-with unidirectional currents of fluctuating velocity.

E



Crevasse channel

Minor mouth bar

EROSIONAL "CREVASSE SPLAYS"

F

Entrenched, crevasse channel

Filled with plant debris, complex laminates, graded silt & sand laminates, mudball conglomerate

erosional contact

Splay lobe or levee deposits

whose migration basinward has completely destroyed pre-existing minor mouth bar deposits (Fig. 62E).

As a result of this research, I have found that a geomorphic entity called a 'crevasse splay' may form by a previously unrecognized process. The fluvial crevasse splays in the study area with their network of anastomozing channels and intervening lobe-like features morphologically resemble crevasse splays in interdistributary bays of the Mississipi River delta plain (i.e. Coleman and Prior, 1980) and fluvial crevasse splays associated with the Brahmaputra River (Coleman, 1969). However the superficial morphologic resemblance is deceptive because the stratigraphy of the crevasse channel and splay lobe deposits reveal that these Mississippi River crevasse splays did not form in an analogous manner. The facies relationships between the channel units and the lobe deposits are completely different from the facies relationships in the two models presented above.

In the splays that I have studied, crevasse channels are U-shaped and entrenched through their associated lobe deposits to the depth (8 m) of the pre-avulsion flood basin deposits (Fig. 61B). A sharp erosional contact separates the crevasse channel fill from the surrounding rhythmically layered and pervasively burrowed splay lobe and levee deposits. The crevasse channel fill is quite fine-grained and is more akin to a clay plug facies in abandoned channels of the Mississippi River system.

A vertical sequence through crevasse channel fill shows erosion-based mudball conglomerate overlain by a relatively fine-grained channel fill which is interpreted as representing various stages of crevasse channel stagnation, reactivation and stabilization by plants

(Fig. 62F). This sequence markedly contrasts with the sequences summarized by Elliott (1974) (Fig. 62 A, B, C, D, E) principally because the channel facies do not consist of the sharp-based cross-stratified lenticular channel sand units which are important components of both the crevasse splay mechanism and minor mouth bar/crevasse channel couplet model described above. Principal lithologies instead consist of mudball conglomerate, macerated plant debris, complex laminates, sets of graded beds, and mottled muddy sand with only a minor ripple laminated sand facies.

In the study area the splay lobe sands differ considerably from the thick, sharp-based, non-burrowed, fining-upward cross-stratified sands described above as crevasse splay lobe and minor mouth bar facies. They consist of very broad sheets of thinly (cm) to minutely (mm) layered rhythmic beds of sand, silt, and clay which are commonly pervasively burrowed with burrowed basal contacts and with only remnants of very small-scale ripple and parallel lamination preserved (Fig. 61B). The lobe deposits are sharply separated from crevasse channels and their finer grained fill (Fig. 61B).

In the minor mouth bar/crevasse channel couplet model (Fig. 61C) channel and bar facies are similar sedimentologically and are lateral facies equivalents. A coarsening upward sequence of thicker and coarser sand beds is generated during the progradation of the bar. A channel-shaped sharp erosive contact is generated at the base of the crevasse fill during progradation of the channel through the bar deposits. The channel is then filled with cross-stratified sand.

In the crevasse splay model (Fig. 61D) it is difficult to separate the channel facies from the lobe facies. Presumably each crevasse splay or incursion of sediment laden water results in the deposition of a sharp-based fining-upward cross-stratified sand in a broad U-shaped trough. The deepest part of the trough would function as the channel proper while the shallower sides would serve as lobes. Lobe and channel deposits would be intergradational.

Singh (1972) observed that natural levee deposits consist of trough-shaped, broad, shallow channels which are oeriented at right angles to the stream and filled with concave-upward curved laminae (channel-fill cross-bedding). The laminae consist of alternating layers of sandy silt and clayey material. These features were attributed to the process of crevasse splaying. Coleman (1969) observed relatively thick, sharp-based sands capped by clay layers throughout the levees and suggested that levees may be constructed as a series of overlapping crevasse splays oriented at right angles to the stream.

A typical vertical sequence through a splay lobe deposit in the study area was arranged as a stack of rhythmic beds from which it was possible to recognize an avulsion sequence related to establishment of the meander belt, two progradational phases of levee or crevasse splay development caused by the migration of meander loops towards the site over time, and individual flood events. Individual sheet flood deposits (mm-cm thick) were packaged together as small-scale (dm thick) fining or coarsening upward sequences that could be interpreted as fluctuations in flood magnitude or climate over time. Progradational phases were present as 1 to 4 m thick packages that initially coarsened upward and then fined slightly upward. Progradations were abruptly terminated by neck cut-offs, indicated by facies change from silt to clay deposition. This sequence most closely resembles

Elliott's (1974) levee progradation sequence (Fig. 62A) because the thick sharp-based cross-stratified sand units are missing.

In the study area the crevasses were probably initiated as small cuts in topographic lows in the levee which became deeply entrenched when a large volume of flood water was pirated from the main stream during a major flood and was able to erode down into the underlying flood basin clays. Once such large crevasses were entrenched they stayed there, easily reactivated during the next flood season and acting as sources of sheet flow to the local flood basin. The sheet like nature of the deposits, the fining upward sedimentary sequence between coarse and fine layers, the minute interlayering in distal levee and distal splay lobes and the systematic decrease in bedding thickness, grain size and degree of burrowing relative to distance crevasses and main channels all attest to a sheet flow origin for both levee and crevasse splay deposits.

Thus in the study area the splay lobes and crevasse channels are not depositional features that developed because of the basinward progradation of minor mouth bars, crevasse channels, lenticular channel sands, and lobes with sheet-like barforms. Rather, after an initial episode of crevasse formation, the splay lobes were incrementally emplaced rhythmite by rhythmite from overbank floods and sheet flow sedimentation. In this particular setting, sheet flows originated along crevasses and the main channel so that the lobe-like features on the splays between the crevasses as well as the flat, featureless levee along the main stream were being affected by this depositional process. The broad sheets of thinly interlayered sediment indicate that individual sheet flows occurred over areally extensive (hundreds of meters) slight, topographic lows that preferentially pirated the sheet flows.

If each sand bed in both levee and splay sequences is considered to have been deposited by the crevasse splay mechanism as suggested by Coleman (1969) then associated channels are ephemeral, of low relief and not recognizable in cores. If channels are not recognizable, then the entire levee and splay lobe sequence is a stack of overlapping broad, thin sheet flow sands. This result differs considerably from previous views that levees form from overbank flooding and sheet flow and crevasse splays form from the process of crevassing which includes the crevasse splay mechanism and the progradation of a minor mouth bar and crevasse channel couplet mechanism.

Even though basal contacts on coarse layers are obscured by burrows which extend upward into overlying sands, the sheet flows at least proximally were probably initially upper flow regime as indicated by the basal parallel laminations. As flow strength decreased into lower flow regime conditions very small sets of ripple laminated very fine sand and coarse silt was deposited. As the flow completely waned, successively finer laminations were emplaced from suspension. The mud cap at the top of the sequence after subaerially exposed was burrowed and eventually penetrated by roots. Sedimentation from successive sheet floods buried the rooted mud.

Ripple drift cross-stratification, an important component of both levee and crevasse splay sands described by Coleman (1969) and Singh (1972) is conspicuously absent here. Singh (1972) also observed in Gomti River deposits that small-scale ripple bedding and ripple-drift cross-stratification were present in meter-thick beds not in mm-cm thick beds with very small ripple forms and very thin sets like in the Mississippi River levees and splays. In Mississippi River deposits, such thick sets of ripple drift are restricted to elongate bar-like forms on both the upper point bar (scroll-bars) (see Ray, 1976 for descriptions) and on concave benches. Even though levees (concave side) and scroll bars (convex side) both act as 'banks' during high water the natural levee and scroll-bars are not analogous features. They form from different sedimentary processes at flood stage: overbank flooding and sheet flow along the cutbank side and scroll-bar accretion in flow separation zones by channel margin processes on the point bar side. Burrowed lithologies were not reported by these workers. Even the mud drapes left between floods were commonly well laminated. Contacts between beds were sharp and erosional, not burrowed.

The burrows for the most part are subhorizontal and concentrated in muddy layers indicating that deposit feeders worked the substrate immediately after each sheet flood. Sporadic nearly vertical backfilled burrows of the same type which extend between mud-rich layers and destroy sharp basal contacts on sandy layers probably are escape structures. It is possible that the basal parallel laminations in the coarse layers are lower flow regime in origin. If this is the case, the sheet flood rose in stream power and then waned under lower flow regime conditions only. This interpretation could also account for the absence of erosional contacts at the base of the coarse layers and the preservation of an inundated surficial pelleted substrate along this contact. The proximality trend in stratification, bedding thickness and grain size indicates that distally flow strength was lower, less competent and shallower with only very thin silt drapes being deposited as the coarser layer. Less sediment was available to deposit from suspension distally.

Dunes are missing from the sedimentary sequence attributed to a single sheet flood because the flow is too shallow, the grain size is too small and the concentration of suspended sediment is too low to allow a bedform the size of a dune to accummulate. It is also possible that the sheet flow occurred as flash floods that didn't exist long enough for dunes to form. Ripple-drift is missing because waters containing a large volume of suspneded sand are not entering the flood basin. The crevasses are tapping water from the main stream about 20-30 ft below the highest flood stage on the cutbank side of the stream. Only the finest material is in suspension this high in the water column on the cutbank side. So a huge supply of sand is not entering the crevasses. Thus the lobe deposits are only locally sandy in narrow levees along the crevasses.

Previous to this study proximality trends in fluvial settings were reported only as grain size decreases (i.e. Kesel, et al 1974) and bedding thickness decreases (Singh, 1980) relative to increasing distance from source. Here it is stressed that 1) the proximality trend in levee and crevasse splay stratification and its close association with burrowing effects and layer thickness have not been previously reported and that 2) levee deposits are much more complicated than simply consisting of alternating coarse and fine layers. In these deposits, with increasing distance from the main channel and crevasses sandy rhythmites were successively replaced by finer-grained and more thinly interlayered deposits such as silty rhythmites and interlaminated silt and clay. As layering thins distally so that burrowers could more completely disrupt it, the stratification grades into pelletal silt, pelletal mud and ultimately the pelletal clay of the backswamp. Splay lobes for the most part consist of pelletal silt which originates as minutely interlaminated silt and clay which is subsequently burrowed into a pelletal silt fabric. Thus levee and splay lobe deposits are virtually identical except that the same lithofacies extend further basinward on splays than they do on levees. Such widespread burrowed lithologies have never previously been reported in levee and crevasse splay deposits especially in the coarser layers.

Rhythmic bedding is also quite typical for interdistributary bay fill sequences or 'crevasse deposits' on the Mississippi Delta. However, the character of the interstratification in bay-fill deposits is different and structures indicating subaerial exposure are missing. Features such as lenticular bedding, graded coarse layers, sharp contacts between coarse and fine layers, and relatively thick intervals of cross-stratified sand are common in interdistributary bay fill but are not present in the levee and splay deposits.

Bioturbation may be locally pervasive in an interdistributary bay, but the nature of the trace fossil assemblage especially in interlaminated sand and clay facies is quite different from that observed in my study area which is further inland. The pervasive pelleted internal backfilling of *Muensteria's* cyclindrical burrows is missing.

Muensteria is not an environment specific ichnogenus. In continental rock associations *Muensteria* has been previously reported in ancient fluvial (Bown, 1972; Bracken and Picard, 1984; Squires and Advocate, 1984) and ancient glacial lake deposits (see Ekdale et al, 1984, p.166). Non-marine clastics, continental red beds, and flood plain deposits normally are associated with the *Scoyenia* inchofacies assemblage (Seilacher, 1967). *Muensteria* has also been observed in upper Cretaceous, marine, storm-influenced, low energy offshore environments and is an important component of the *Skolithos/Cruziana* ichnofacies in this setting (Pemberton and Frey, 1983; 1984). Here *Muensteria* is recognized as being a pervasive, characteristic trace in fully terrestrial Holocene flood basin deposits in the lower Mississippi Valley.

The architecture of a fluvial sequence refers to the three-dimensional geometry and interrelationships of the deposits of the channel, levee, crevasse, floodplain and other sub-environments of a fluvial depositional system (Miall, 1983). Several examples of fluvial arcitecture in overbank regions are shown in Figure 61.

Johansen (1983) uses the term 'thick splay style' to describe fluvial sequences containing abundant splay sandstones which are very thick relative to the total thickness of associated channel sandstones. These thick sand beds are attributed to either of the crevassing mechanism. The sandstone bodies are probably emplaced subaqueously during a discrete depositional event.

Along the same line of reasoning, 'thin splay style' includes splay and levee sandstones which are very thin relative to the total thickness of the channel belt sandstones. This type of splay lobe is incrementally emplaced, rhythmite by rhythmite and is built up over a period of time by a succession of sheet flood events.

The differences in the fluvial system that result in thick or thin splay style may be related to such factors as the suspended load-bedload ratio, the position in the flood basin, or paleoclimate. Splaying can occur under either subaerial or subaqueous conditions in environments that range from coast-wise interdistributary bays to totally subaerial fluvial deposits. Thick splay style may indicate a predominantly sandy system where crevasses cross-cut sandy, easily eroded banks that tap a predominantly sandy bedload from the deepest parts of shallow main channels. Deposition of the splay is probably subaqueous.

Thin splay style may mean that permanent crevasses are entrenched into flood basin clays, crevasses are tapping only the upper parts of the water column from huge main channels where the suspended load is greater than the bedload and flood waters are transported into a filling flood basin. Preponderance of burrowing in the splay sands indicates subaerial exposure.

The stacking and relative thicknesses of lithofacies or even sand beds in levee, splay and backswamp deposits should answer questions about periodicity and magnitude of flooding and the relative proportion of bedload to suspended load being transported. If overbank sequences are studied in a variety of modern fluvial systems (i.e. meandering, anastomozing, braided) and in a variety of different climates, it is likely that sequence patterns will emerge which will ultimately aid in assessing the channel pattern, paleoclimate and the avulsion history in ancient alluvial sequences.

CHAPTER 7: CONCLUSIONS

1) The Holocene flood basin along a meander belt margin of the Mississippi River includes two principal geomorphic features: a flat nearly featureless natural levee which dips gently towards and merges gradually with the backswamp, and a system of anastomozed, entrenched crevasse channels with intervening lobe-like features which morphologically resemble a classic 'crevasse splay'. The sedimentology of this crevasse splay-like entity is identical to the sedimentology of the associated natural levee deposits which reveals that it formed in an analogous manner, by a previously unrecognized process, the process of sheet flow sedimentation. These features will be referred to as crevasse channels and splay lobes.

2) Levee and splay lobe deposits consist of thinly (cm) to minutely (mm) rhythmically layered sand, silt and clay which are pervasively disrupted by unlined meniscate burrows of the trace fossil, *Muensteria*. Traces of primary stratification include only small-scale ripple laminations and parallel laminations in the coarser layers. Pelletal fabrics develop where overlapping backfilled burrows completely obliterate primary stratification. Deposits from a single sheet flood range in thickness from millimeters to several decimeters. Clay-rich layers commonly contain roots replaced or coated by concretionary material such as Fe-oxides and probable Fe-carbonates.

3) Backswamp deposits consist of thick, non-stratified rooted clays which are for the most part disrupted into pelletal fabrics by the trace fossil *Muensteria*. Conglomeratic mudball beds and pelletal silts are also present in the subsurface at the base of the backswamp

sequence.

4) The trace fossil, *Muensteria*, is not environment specific and has been previously reported in rock assemblages interpreted as clastic marine shelf, glacial lake and fluvial deposits. This is the first report that *Muensteria* is pervasive and a major component of sediment fabric in Holocene flood basin levee, splay lobe and back-swamp deposits in a meandering river system.

5) The rhythmic stratification in the levee and splay lobe deposits is quite intricate in its distribution between the margin of the flood basin and the backswamp. A proximality trend in stratification is present relative to the trunk channel and crevasse network, both of which acted as sources for overbank floods. The thickest sandy rhythmites are present in a narrow zone along the trunk channel and along crevasses near their heads. With increasing distance from the trunk channel and crevasses, sandy rhythmites are successively replaced by finer-grained and more thinly interlayered deposits such as silty rhythmites and interlaminated silt and clay. As layering thins distally so that burrowers more effectively disrupt primary interlayering, the stratification grades into pelletal silt, pelletal mud and ultimately the pelletal clay of the backswamp.

6) Previous studies reported proximality trends in fluvial settings as grain size and bedding thickness decreases relative to increasing distance from source. Here it is stressed that the proximality trend in levee and crevasse splay stratification and its close association with burrowing effects and layer thickness have not been previously reported and that the alternating coarse and fine layering is much more complicated than previously supposed.

7) Splay lobe and levee deposits for the most part consist of extensive zones of pelletal silt which originate as minutely interlaminated silt and clay which is subsequently burrowed into a pelletal silt fabric. Thus levee and splay lobe deposits are virtually identical except that the same lithofacies extend further basinward on splays than they do on levees. Such widespread burrowed lithologies have never previously been reported in levee and crevasse splay lobe deposits.

8) The sheet like nature of the deposits, the fining upward sedimentary sequence from the coarse to the fine layers, the minute interlaminations of distal levee and distal splay lobes and the systematic decrease in bedding thickness, grain size and degree of burrowing relative to distance from crevasses and main channels indicate that both levee and crevasse splay deposits were emplaced by the same sedimentologic process, overbank flooding and sheet flow. This result differs considerably from previous views that levees form from overbank flooding and sheet flow and crevasse splays form from the process of crevassing which includes the crevasse splay mechanism and the progradation of a minor mouth bar and crevasse channel couplet mechanism.

9) Crevasse channels are U-shaped in cross-section and are deeply entrenched into the surrounding levee and splay lobe deposits to the depth (8 m) of the pre-avulsion flood basin deposits. The crevasse channel fill does not consist of lenticular channel sand units which are a lateral facies equivalent of the thick sheet-like sands of splay lobes in the two models for crevasse deposits summarized by Elliott (1974). Rather it is quite fine-grained and is more akin to a clay

plug facies in abandoned channels of the Mississippi River system. Principal lithologies instead consist of mudball conglomerate, macerated plant debris, complex laminates, sets of graded beds, and mottled muddy sand in addition to a minor ripple laminated sand facies.

10) The thick fining-upward cross-stratified sands with sharp erosional bases described in modern interdistributary bay crevasse splays, modern fluvial crevasse splays, and ancient fluvial crevasse splays are not a component of these 'crevasse splays'. These splay lobe deposits are very thinly layered, pervasively burrowed, with burrowed contacts and with only remnants of very small-scale ripple and parallel lamination preserved. The crevasses are deeply entrenched into the lobes and do not contain extensive sandy facies. Therefore these crevasse channels and splay lobes are not depositional features that developed because of the basinward progradation of minor mouth bars, crevasse channels, lenticular channel sands, and lobes with sheet-like barforms. Rather, after an initial episode of crevasse formation, the splay lobes were deposited in a manner exactly analygous to deposition on associated levees, by overbank flooding and sheet flood sedimentation. The crevasses were probably initiated as small cuts in topographic lows in the levee which became deeply entrenched when a large volume of flood water was pirated from the main stream during a major flood and was able to erode down into the underlying flood basin clays. Once such large crevasses were entrenched they stayed there, easily reactivated during the next flood season.

11) The establishment of the meander belt at its present location

in the flood basin is recorded as a lithologic change from pelletal sandy silt (FB2) (a distal splay lobe deposit) to the mudball conglomerate (FB3) in the backswamp section. The mudball conglomerate was emplaced during a period of intense flood activity that was associated with the avulsion of the meander belt to its present site. This same event is recorded in the levee and splay lobe sequence as a lithologic change from lake and swamp clays (FB1) to pelletal clayey silt (FB5), a more subaerial deposit, near the new trunk channel.

12) After establishment of the meander belt two episodes of levee and/or splay progradation are recorded by the sequence through the levee and splay lobe deposits. Each progradation is about 3-4 m thick, represents the gradual migration of the trunk channel towards the site over time, and abruptly ends with a neck cut-off.

The lower progradational event consists of the following succession: blue clay (FB1) of subaqueous lake and swamp origin is replaced up-section by more sub-aerial deposits as a levee built up along the new trunk channel: burrowed and rooted pelletal clayey silt (FB5), rhythmically bedded and burrowed sands, silts and clays (FB6 and FB7). Rooted clays (FB8, FB4) were deposited between major phases of progradation.

The upper progradational event is present as a rhythmically layered and burrowed sand, silt and clay (FB10) which commonly initially coarsens and then fines slightly upward into pelletal silt.

13) Crevasse channel fill (3.5 m) consists of 1) a lower zone of organic-rich clay, wood and plant debris and branches (CB1), 2) an intermediate cross-laminated and graded silt and sand (CB2, CB3, CB4), and 3) an upper mottled muddy sand (CB5). This sequence is inter-

preted respectively as periods of: 1) standing water sedimentation in a blocked crevasse, 2) sustained flow, and 3) periodic flow alternating with periods of standing water deposition and bioturbation.

BIBLIOGRAPHY

AIGNER, T.A., AND REINECK, H.E., 1982, Proximality trends in modern storm sands from the Helgoland Bight (North Sea) and their implication for basin analysis: Senckenbergiana Maritima, v. 14, p. 183-221.

ALLEN, J.R.L., 1965, A review of the origin and characteristics of Recent alluvial sediments: Sedimentology, v. 5, p. 89-191.

ALLEN, J.R.L., 1978, Achievements and prospects in fluvial sedimentology: *In* Miall, A.D., ed., Fluvial Sedimentology, Canadian Society of Petroleum Geologists, Memoir 5, Calgary, Alberta, Canada, p. 849.

ARNSDORFER, D.J, 1973, Discharge patterns in two crevasses in the Mississippi River delta; Marine Geology, v. 15, p. 269-287.

BLATT, H., MIDDLETON, G., AND MURRAY, R., 1980, Origin of Sedimentary Rocks: Prentice-Hall, Inc., New Jersey, 782 pp.

BLUCK, B.J., 1971, Sedimentation in the meandering river Endrick: Scottish Journal of Geology, v. 7, p. 93-138.

BOWN, T.M., 1982, Ichnofossils and rhizoliths of the nearshore fluvial Jebel Quatrani Formation (Oligocene), Fayum Province, Egypt: Palaeogeogr., Palaeoclimatol., Palaeoecol., v. 40 p. 255-309.

BRACKEN, B. AND PICARD, M. D., 1984, Trace fossils from Cretaceous/ Tertiary North Horn Formation in central Utah: Journal of Paleontology, v. 58, no. 2, p. 477-487.

BRIDGE, J.S., 1985, Paleochannel patterns inferred from alluvial deposits: a critical evaluation: Journal of Sedimentary Petrology, v. 55, no. 4, p. 579-589.

BRIDGE, J.S., 1984, Large-scale facies sequences in alluvial overbank environments: Journal of Sedimentary Petrology, v. 54, p. 583-588.

BRIDGE, J.S., AND GORDON, E.A., 1985, Field Trip 1, The Catskill Magnafacies of New York State: *In* Flores, Romeo M. et al., editors, Field Guidebook to modern and ancient fluvial systems in the United States, Third International Fluvial Sedimentology Conference, Ft. Collins, CO., p. 3-17.

BRIDGE, J.S., AND LEEDER, M.R., 1979, A simulation model of alluvial stratigraphy: Sedimentology, v. 26, p. 617-644.

CAREY, W.C., 1963, Turn mechanisms of alluvial rivers: Military Engineer, Jan.-Feb., p. 14-16.

CAREY, W.C., 1969, Formation of flood plain lands: Journal of Hydraulic Division, American Society of Civil Engineers, v. 95, p. 981-994.

CHAMBERLAIN, C.K., 1975, Recent Lebenspurren in nonmarine aquatic environments: *In* Frey, R.W., editor, The study of Trace Fossils, Springer-Verlag, N.Y., p. 431-458.

COLEMAN, J.M., 1966, Ecological changes in a massive fresh-water clay sequence: Transactions-Gulf Coast Association of Geological Societies, v. XVI, p. 159-174.

COLEMAN, J.M., 1969, Brahmaputra River - channel processes and sedimentation: Sedimentary Geology, v. 3, p. 129-239.

COLEMAN, J.M., 1981, Deltas: Processes and Modes of Deposition for Exploration. Coastal Studies Institute, Louisiana State University, Minneapolis, MN.

COLEMAN, J.M., AND GAGLIANO, S.M., 1964, Cyclic sedimentation in the Mississippi River deltaic plain: Transactions Gulf Coast

Association of Geological Societies, v. 14, p. 67-80

COLEMAN, J.M., AND PRIOR, D., 1980, Deltaic Sand Bodies, American Association of Petroleum Geologists Continuing Education Course Note Series #15.

COLLINSON, J.D., 1978, Vertical sequence and sand body shape in alluvial sequences, *In* Miall, A.D., Fluvial Sedimentology, Canadian Society of Petroleum Geologists, Memoir 5, Calgary, Alberta, Canada, p. 577-586.

COLLINSON, J.D., 1986, Alluvial Sediments, In Reading, H.G., ed., Sedimentary Environments and Facies: Elsevier, NY, p. 20-62.

CROSS, T.A., AND SMITH, N.D., 1985, Comparative anatomy of contemporary and ancient crevasse splay and anastomosed crevasse channel complexes: Abstract, Third International Fluvial Sedimentology Conference, Fort Collins, Colorado, August 7-9, 1985.

DAVIES, D.K., 1966, Sedimentary structures and sub-facies of a Mississippi River point bar: Journal of Geology, v. 74, p. 234-239.

EKDALE, A.A., BROMLEY, R.G., AND PEMBERTON, S.G., 1984, Ichnology: Trace fossils in sedimentology and stratigraphy: SEPM Short Course No. 15, Society of Economic Paleontologists and Mineralogists, Tulsa, OK.

ELLIOTT, T., 1974, Interdistributary bay sequences and their genesis: Sedimentology, v. 21, p. 611-622.

FIELDING, C.R., 1984, Upper delta plain lacustrine and fluviolacustrine facies from the Westphalian of the Durham coalfield, NE England: Sedimentology, v. 31, 547-567.

FISK, H.N., 1944, Geological investigation of the alluvial valley of the lower Mississippi River: Mississippi River Commission, Vicksburg, Mississippi, 82 pp.

FISK, H.N., 1947, Fine grained alluvial deposits and their effects on Mississippi River activity: Mississippi River Commission, Vicksburg, Mississippi, 74 plates.

FRAZIER, D.E., AND OSANIK, A., 1961, Point bar deposits, Old River Locksite, Louisiana: Transactions of the Gulf Coast Association of Geological Societies, v. 11, p. 121-137.

FREY, R.W., PEMBERTON, S.G., AND FAGERSTROM, J.A., 1984, Morphological, ethological and environmental significance of the ichnogenera *Scoyenia* and *Ancorichnus*: Journal of Paleontology, v. 58, no. 2, p. 511-528.

FRIEND, P.F., 1983, Towards the field classification of alluvial architecture or sequence, *In* Collinson, J.D. and Lewin, J., editors, Modern and Ancient Fluvial Systems: International Association of Sedimentologists, Special Publication No. 6., Blackwell Scientific Publications, Oxford, England, p. 345-354.

FROSTICK, L.E. AND REID, I., 1977, The origin of horizontal laminae in ephemeral stream channel fill: Sedimentology, v. 24, p. 1-9.

GESTALDO, R.A, DOUGLASS, D.P. AND MCCARROLL, S.M., 1987, Origin, characteristics and provenance of plant macrodetritus in a Holocene crevasse splay, Mobile Delta, Alabama: Palaios, v. 2, p. 229-240.

GORDON, E.A. and BRIDGE, J.S., 1987, Evolution of Catskill (Upper Devonian) river systems: intra- and extrabasinal controls: Journal of Sedimentary Petrology, V. 57, p. 234-249.

HARMS, J.C., MACKENZIE, D.B., AND MCCUBIN, D.G., 1963, Stratification in modern sands of the Red River, Louisiana: Journal of Geology,

v. 71, p. 566-580.

HARMS, J.C., SOUTHARD, J.B. AND WALKER, R.G., 1982, Structures and sequences in clastic rocks: Society of Economic Paleontologists and Mineralogists, Short Course 9, second edition, variable pagination.

HAYES, K.J., 1985, Morphodynamics of a Mississippi River meander bend: Thesis, Louisiana State University, Baton Rouge, Louisiana.

HICKIN, E.J., 1978, Concave-bank benches on the Squamish River, British Columbia, Canadian Journal of Earth Sciences, v. 16, p. 200-203.

HO, CLARA AND COLEMAN, J.M., 1969, Consolidation and cementation of Recent sediment in the Atchafalaya Basin: Geological Society of America Bulletin, v. 80, p. 183-191.

HOYT, W.H. AND DEMEREST III, J.M., 1981, Vibracoring in coastal environments: a description of equipment and procedures: DEL-SG-01-81, Sea Grant College Program, University of Delaware., Newark, Delaware, p. 20-31.

HUGHES, D.A., AND LEWIN, JOHN, 1982, A small scale flood plain: Sedimentology, v. 29, p. 891-895.

JACKSON, R.G. II, 1976A, Depositional model of point bars in the lower Wabash River: Journal of Sedimentary Petrology, v. 46, p. 579-594.

JACKSON, R.G. II, 1976B, Large scale ripples of the Lower Wabash River: Sedimentology , v. 23, p. 593-623.

JACKSON, R.G. II, 1978, Preliminary evaluation of lithofacies models for meandering alluvial streams, *In* Miall, A.D., ed., Fluvial Sedimentology: Canadian Society of Petroleum Geologists, Memoir 5, Calgary, Alberta, Canada, p. 543-576.

JOPLING, A.V. AND WALKER, R.G., 1968, Morphology and origin of ripple-drift cross-lamination with examples from the Pleistocene of Massachusetts: Journal of Sedimentary Petrology, v. 38, p. 971-984.

JOHANSEN, S.J., 1983, The thick splay depositional style of the Crevasse Canyon Formation, Cretaceous of West-Central New Mexico: *In* Chapin, C.E., editor, Socorro Region II, Guidebook, New Mexico Geological Society, 34, p. 173-178.

KAPPA,, J.D., PRYOR, W.A., AND JORDAN, D.W., 1987, A Mississippi River crevasse splay deposit: Abstract, SEPM, Annual Midyear Meeting 4, p. 41, August 23, 1987, Austin TX.

KESEL, R.H, DUNNE, K.C., McDONALD, R.C., ALLISON, K.R., AND SPICER, B.E., 1974, Lateral erosion and overbank deposition on the Mississippi River in Louisiana caused by 1973 flooding: Geology, (Boulder), v. 2, p.461-464.

KRINITZSKY, E.L., AND SMITH, F.L., 1969, Geology of backswamp deposits in the Atchafalaya Basin, Louisiana: United States Army Corps of Engineers, Waterways Experiment Station, Technical Report S-69-8, Vicksburg, Mississippi, 26pp.

LANESKY, D.E., LOGAN, B.W., BROWN, R.G., AND HINE, A.C., 1979, A new approach to portable vibracoring underwater and on land: Journal of Sedimentary Petrology, v. 49, p. 654-657.

LEVEY, R., 1976, Bedform distribution and internal stratification of coarse grained point bars, upper Congaree River, South Carolina, *In* Hayes, M.O., and Kana, T.W., editors, Terrigenous Clastic Depositional Environments: University of South Carolina, Dept. of

Geology, Report 11-CRD.

MCFARLAN, E. JR., 1961, Radiocarbon dating of late Quaternary deposits, South Louisiana: Geological Society of America Bulletin, v. 72, 129-158.

MCGOWEN, J.H. AND GARNER, L.E., 1970, Physiographic features and stratification types of coarse grained point bars, modern and ancient examples: Sedimentology, v. 14, p. 77- 111.

MARTINSSON, A., 1970, Toponomy of trace fossils: *In* Crimes, T.P., and Harper, J.C., eds., Trace Fossils, Geology Journal, Special Issue 3: p. 323-330.

MIALL, A.D., 1983, Basin analysis of fluvial sediments, *In* Collinson, J.D., and Lewin, J., eds., Modern and Ancient Fluvial Systems: Special Publication No. 6, International Association of Sedimentologists, Blackswell Scientific Publications, Oxford, England, p. 279-286.

MIDDLETON, G.V. AND SOUTHARD, 1977, S.E.P.M. Short Course Notes 3, p. 7.37.

NANSON, G.C., 1980, Point bar and flood plain formation of the meandering Beatton River, northeastern British Columbia, Canada: Sedimentology, v. 27, p. 3-29.

NANSON, G.C. AND PAGE, K., 1983, Lateral accretion of fine-grained concave benches on meandering rivers, *In* Collinson, J.D., and Lewin, J., eds., Modern and Ancient Fluvial Systems: Special Publication No. 6, International Association of Sedimentologists, Blackwell Scientific Publications, Oxford, England, p. 145-149.

PEMBERTON, S.G., AND FREY, R.W., 1983, Biogenic structures in Upper Cretaceous outcrops and core: Canadian Society of Peteroleum

Geologists Guidebook 8, 161 pages.

PEMBERTON, S.G., AND FREY, R.W., 1984, Ichnology of storm-influenced shallow marine sequence: Cardium Formation (Upper Cretaceous) at Soebe, Alberta: in Stott, D.F., ed., Mesozoic of middle North America: Canadian Society of Petroleum Geologists Memoir 9.

POTTER, P.E., 1967, Sand bodies and sedimentary facies environments: a review: American Association of Petroleum Geologists Bulletin, v. 51, p. 339-365

POTTER, P.E., MAYNARD, J.B., AND PRYOR, W.A., 1980, Sedimentology of Shale: Springer-Verlag, NY.

RAY, PULAK, 1976, Structure and sedimentological history of the overbank deposits of a Mississippi River point bar: Journal of Sedimentary Petrology, v. 46, p. 788-801.

REINECK, H.E., AND SINGH, I.B., 1980, Sedimentary Depositional Environments, Springer-Verlag, New York, pp.

RETALLACK, G.J., 1983A, A paleopedological approach to the interpretation of terrestrial sedimentary rocks: the mid-Tertiary fossil soils of Badlands National Park, South Dakota: Geological Society of America Bulletin, v. 94, p. 823-840.

RETALLACK, G.J., 1983B, Late Eocene and Oligocene paleosols from Badlands National Park, South Dakota: Geological Society of America, Special Paper 193, Boulder, Colorado.

SAUCIER, R.T., 1969, Geological Investigation of the Mississippi River area, Artonish to Donaldsonville, Louisiana: Technical Report 5-69-4: U.S. Army Engineer Waterways Experiment Station, Corps of Engineer, Vicksburg, Mississippi, 20 Plates.

SAUCIER, R.T., 1974, Quaternary Geology of the lower Mississippi

Valley: Arkansas Archeological Survey, Publications on Archeology, Research Series No. 6.

SEILACHER, A., 1967, Bathymetry of Trace Fossils: Marine Geology, v. 5, p. 413-418.

SINGH, I.B., 1972, On the bedding in the natural levee and the point-bar deposits of the Gomti River, Uttar Pradesh, India: Sedimentary Geology, v. 7, p. 309-317.

SMITH, D.G., 1983, Anastomosed fluvial deposits: modern examples from Western Canada, *in* Collinson, J.D., and Lewin, J., eds., Modern and Ancient Fluvial Systems: Special Publication No. 6, International Association of Sedimentologists, Blackwell Scientific Publications, Oxford, England, p. 155-163.

SMITH, D.G., 1984, Vibracoring fluvial and deltaic sediments: tips on improving penetration and recovery: Journal of Sedimentary Petrology, v. 54, p. 660-663.

SQUIRES, R.L. AND ADVOCATE, D.M., 1984, Meniscate burrows from Miocene lacustrine-fluvial deposits, Diligencia Formation, Orocopia Mountains, southern California: Journal of Paleontology, V. 58, p.593-597.

STEAR, W.M., 1983, Morphological characteristics of ephemeral stream channel and overbank splay sandstone bodies in the Permian Lower Beaufort Group, Karoo Basin, South Africa: *In* Collinson, J.D., and Lewin, J., editors, Modern and ancient fluvial systems, Special Publiciation No. 6, International Association of Sedimentologists, Blackwell Scientific Publications, Cxford, England, p. 405-420.

STERNBERG, H.O.R., 1956, A contribution to the geomorphology of the False River area, Louisiana: Dissertation, Louisiana State

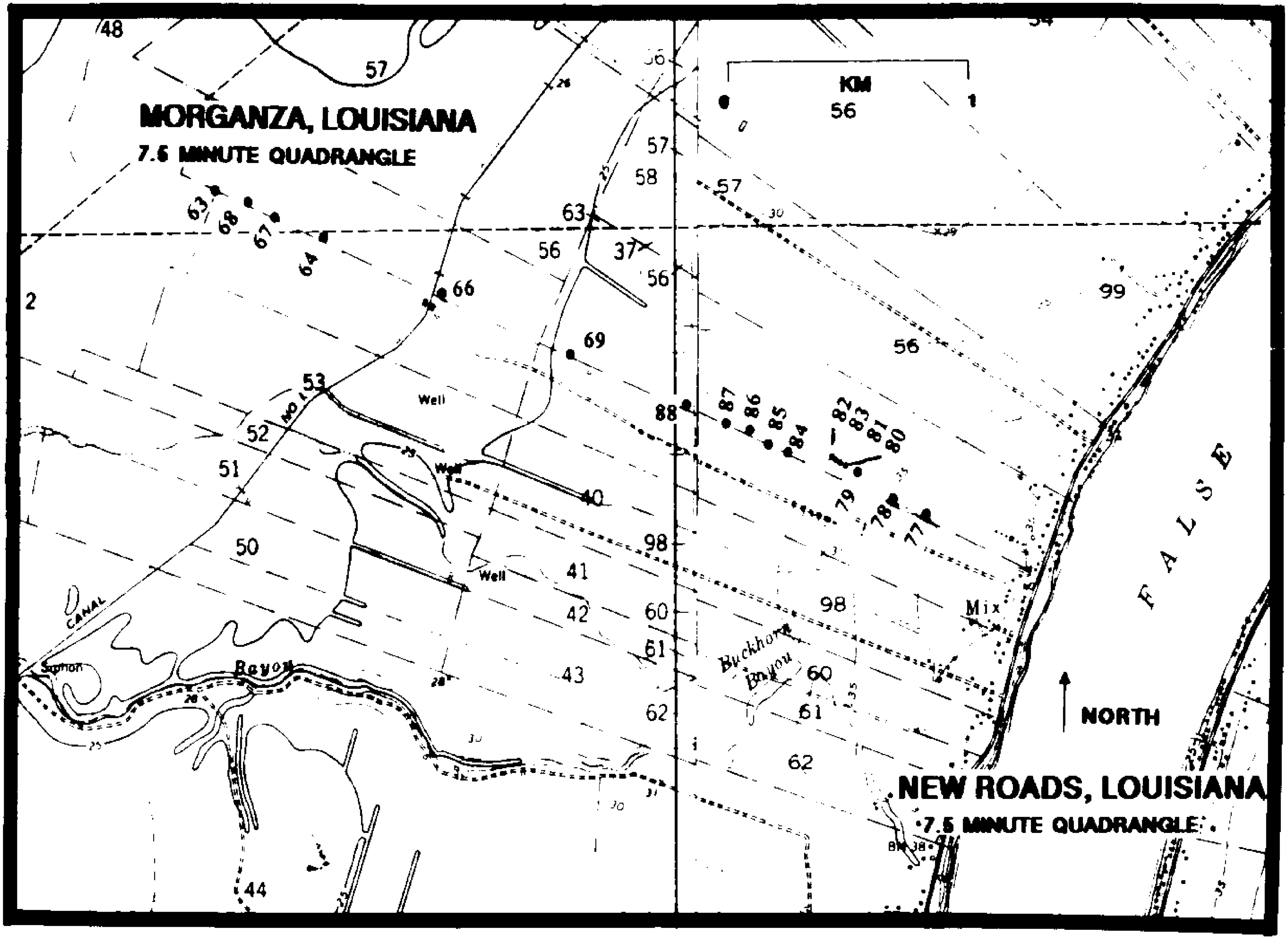
University, Baton Rouge, LA, 169 pp.

TYE, R.S, 1986, Non-marine Atchafalaya deltas; processes and products of interdistributary bay alluviation, South Central Louisiana. 437 pp. Doctoral 1986, Louisiana State University and A&M College, Baton Rouge, Louisiana.

WELLS, R.F., 1977, Fresh water invertebrate living traces of the Mississippi Valley near Baton Rouge, Louisiana. Unpublished M.S. thesis. Louisiana State University, Baton Rouge, Louisiana. 254 pp.

WOLMAN, M.G., AND LEOPOLD, L.E., 1957, River flood plains: some observations on their formation: U.S. Geological Survey, Professional Paper No. 282C , C87-C107.

APPENDIX A: TOPOGRAPHIC MAPS SHOWING CORE LOCATIONS


MORGANZA, LOUISIANA
7.5 MINUTE QUADRANGLE
NEW ROADS, LOUISIANA
7.5 MINUTE QUADRANGLE
KM
0
1
NORTH
FALSE
Well
Well
Well
CANAL
Bayou
Buckhorn Bayou
Mix
63
68
67
64
66
69
53
52
51
50
87
86
85
84
88
82
83
81
80
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43
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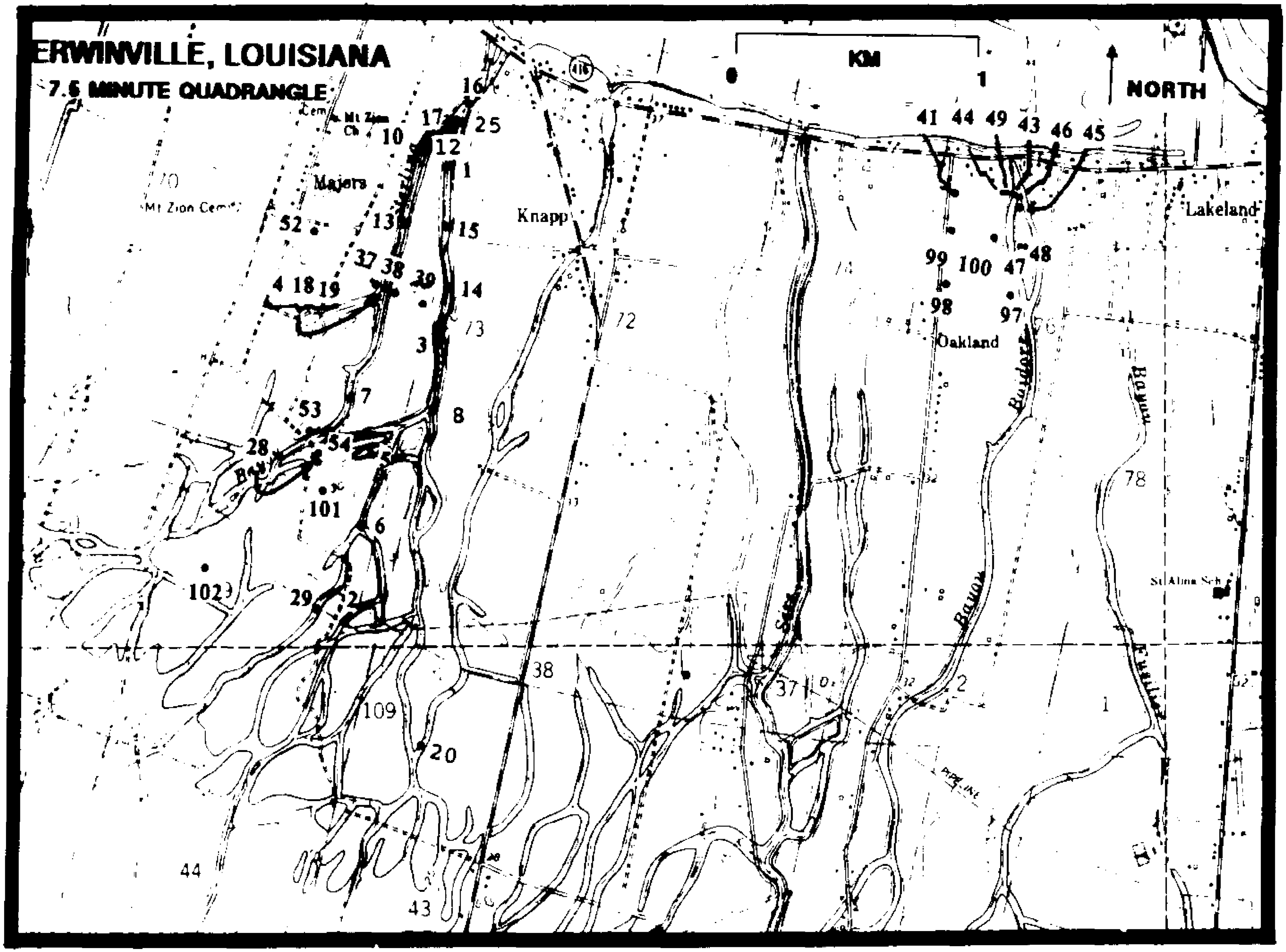
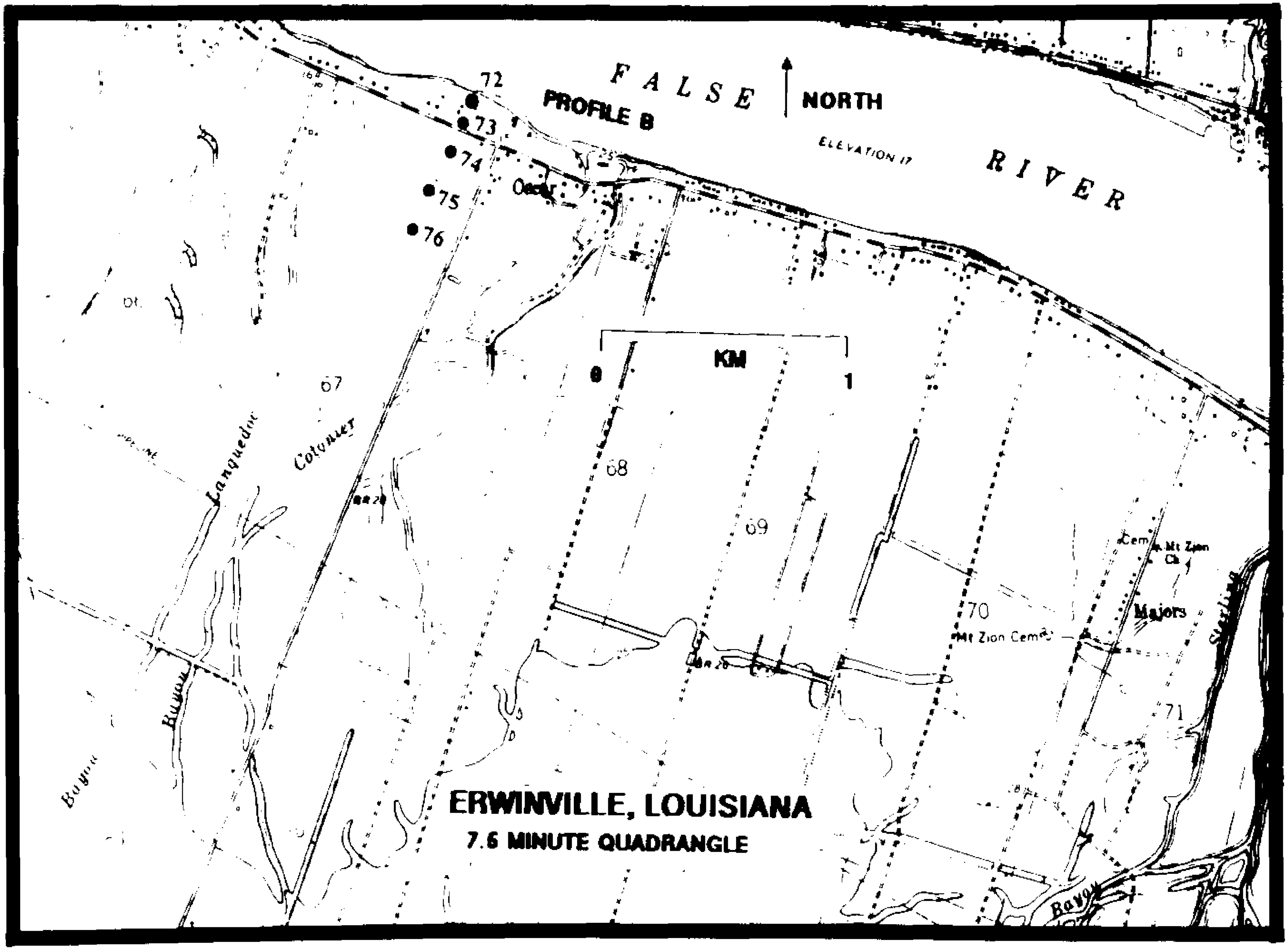
61
62
44
48
2
37
40


ERWINVILLE, LOUISIANA
7.5 MINUTE QUADRANGLE
KM
0
1
NORTH
Majers
Mt Zion Cem
Knapp
Lakeland
Oakland
St Alma Sch
Bayou
PIPELINE
41 44 49 43 46 45
99 100 47 48
98 97
16 17 25 10 12 1
52 13 15
37 38 39 14
4 18 19
3 73 72
53 7 8
28 54
101
6
102
29 22
38 37 2 1 78
109
20
44
43



FALSE RIVER
NORTH
PROFILE B
ELEVATION 17
72
73
74
75
76
Oscar
KM
0
1
67
68
69
70
71
Colonier
Languedoc
Bayou
Bayou
Cem
Mt Zion Ch
Majors
Mt Zion Cem
Sterling
ERWINVILLE, LOUISIANA
7.5 MINUTE QUADRANGLE

KEY TO UNITS IN CORE LOGS

LEVEE AND SPLAY LOBE

FB9 – RHYTHMICALLY LAYERED SAND, SILT, CLAY

FB8 – DARK BROWN PELLETAL MUD

FB7 – PELLETAL SILT

FB6 – RHYTHMICALLY LAYERED SILT

FB5 – BURROWED SILTY CLAY

BACKSWAMP

FB4 – ROOTED CLAY

FB3 – MUDBALL CONGLOMERATE

FB2 – VERY FINE SANDY CLAYEY SILT

FB1 – DARK BLUE CLAY

CONCAVE BENCH

CB5 – SAND (CROSS – STRATIFIED – LAMINATED

CB4 – SAND (GRADED LAMINATIONS)

CB3 – CLAY (ROOTED TO BANDED

CB2 – FINE – GRAINED LAMINATES

CB1 – INTERBEDDED SAND AND CLAY

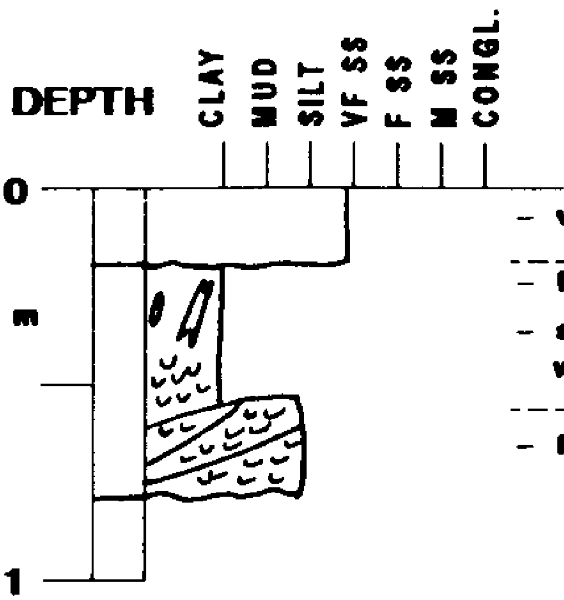
APPENDIX B: KEY TO UNITS IN CORE LOGS

APPENDIX C: KEY TO SYMBOLS IN CORE LOGS

KEY TO SYMBOLS

- RIPPLE CROSS – LAMINATIONS
- PLANAR CROSS – STRATIFICATION
- RIPPLE DRIFT CROSS – STRATIFICATION
- SCOURED SURFACE WITH TANGENTIAL LAMINATIONS
- PARALLEL LAMINATIONS
- CRENULATED LAMINATIONS
- FLAME STRUCTURES
- BURROWED CONTACTS
- WATER ESCAPE STRUCTURES
- CONVOLUTED LAMINATIONS
- LENTICULAR BEDDING
- LARGE ROOT BURROWS
- LARGE BURROW WITH PELLETAL INTERNAL FILL
- PELLETAL FABRIC
- BURROWED LAMINATES
- INCLINED BURROW WITH INTERNAL MENISCATE PELLETAL FILL
- HORIZONTAL BURROW WITH INTERNAL MENISCATE PELLETAL FILL
- MUDBALLS
- CARBONATE NODULES
- LEAVES
- TWIGS
- PEATY SUBSTRATE
- MOTTLEDNESS
- ROOT HAIRS
- COATED ROOT HAIRS
- CARBONATE COATED LEAF FRONDS

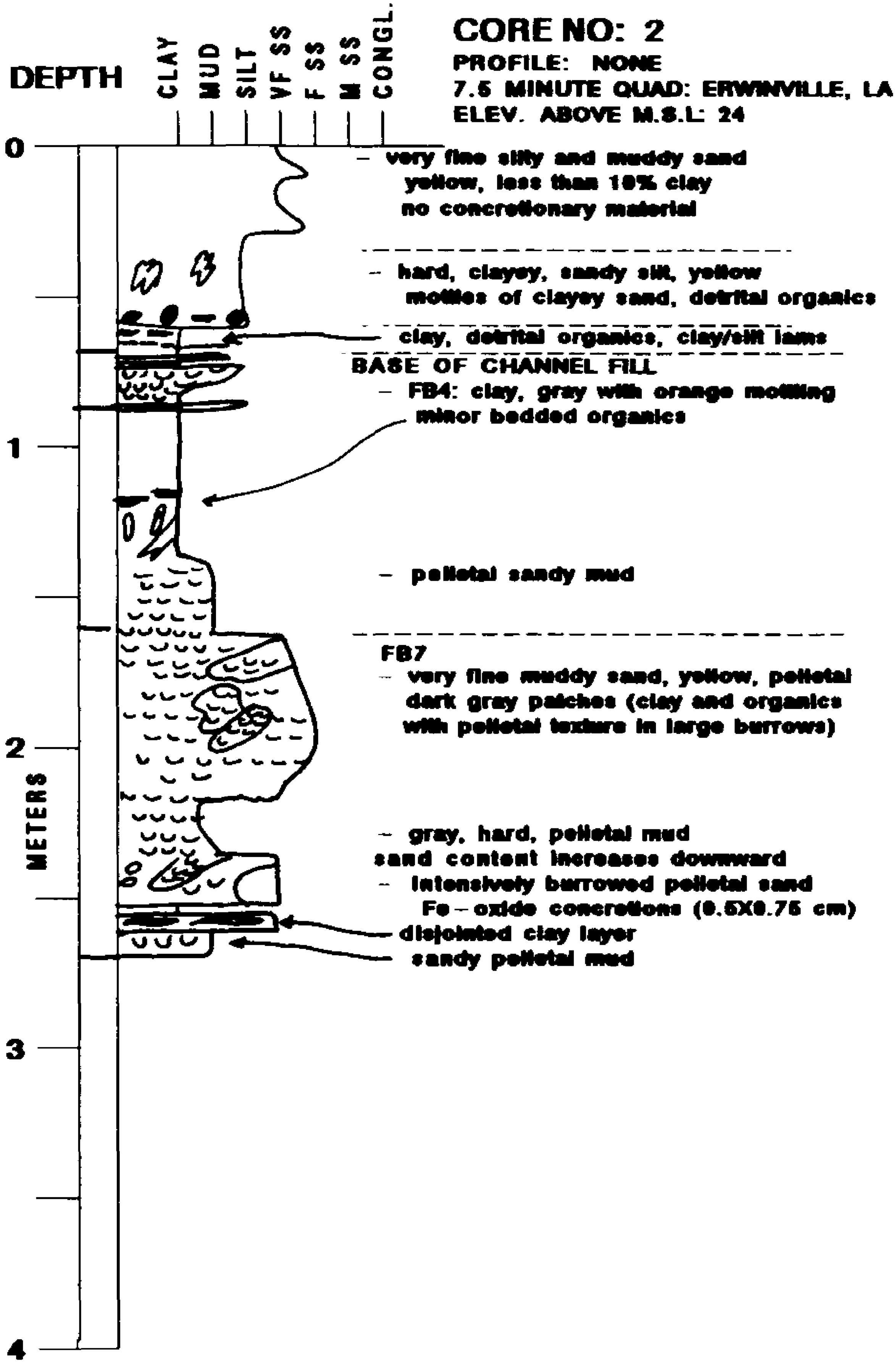
APPENDIX D: CORE LOGS

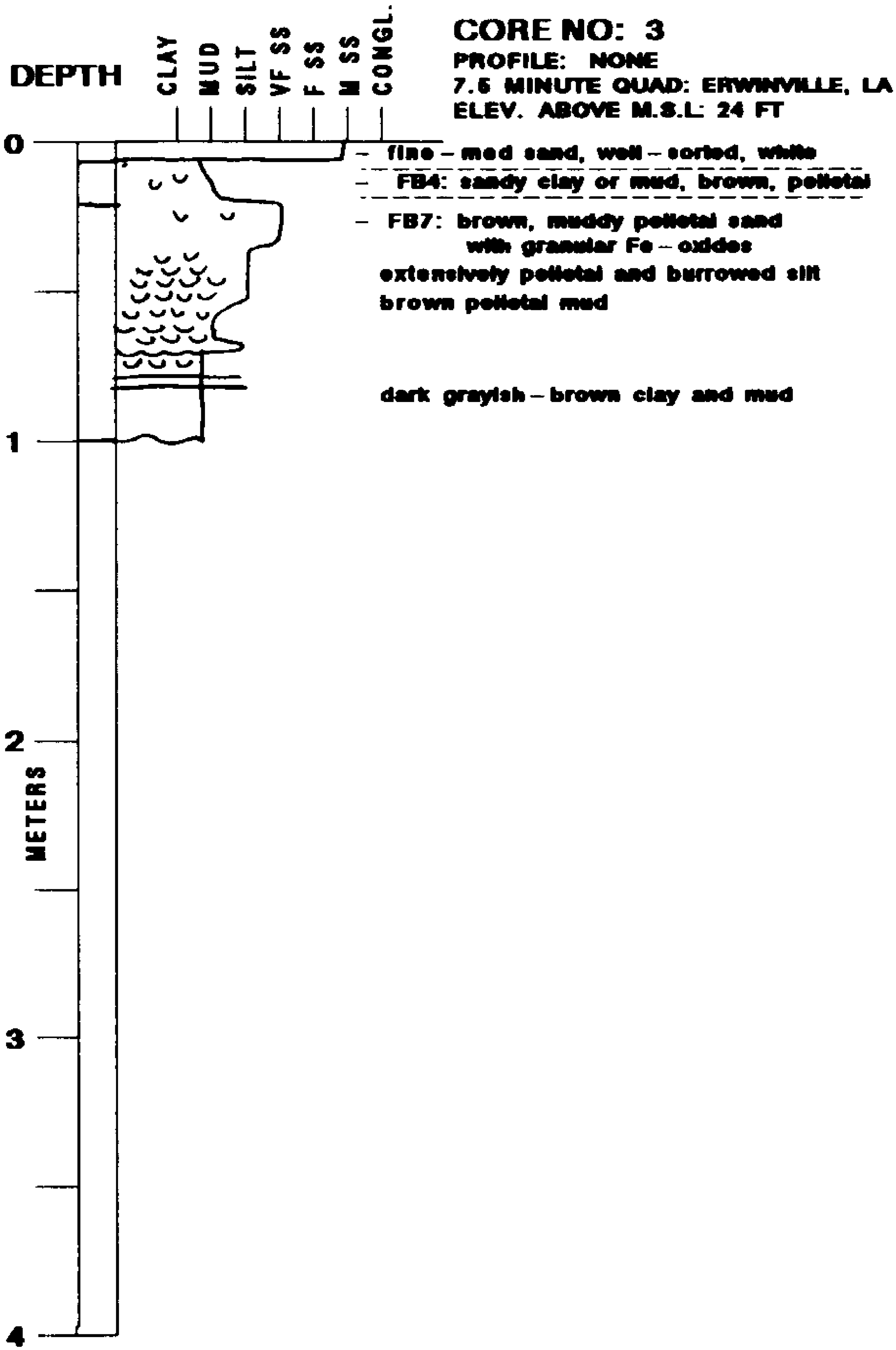


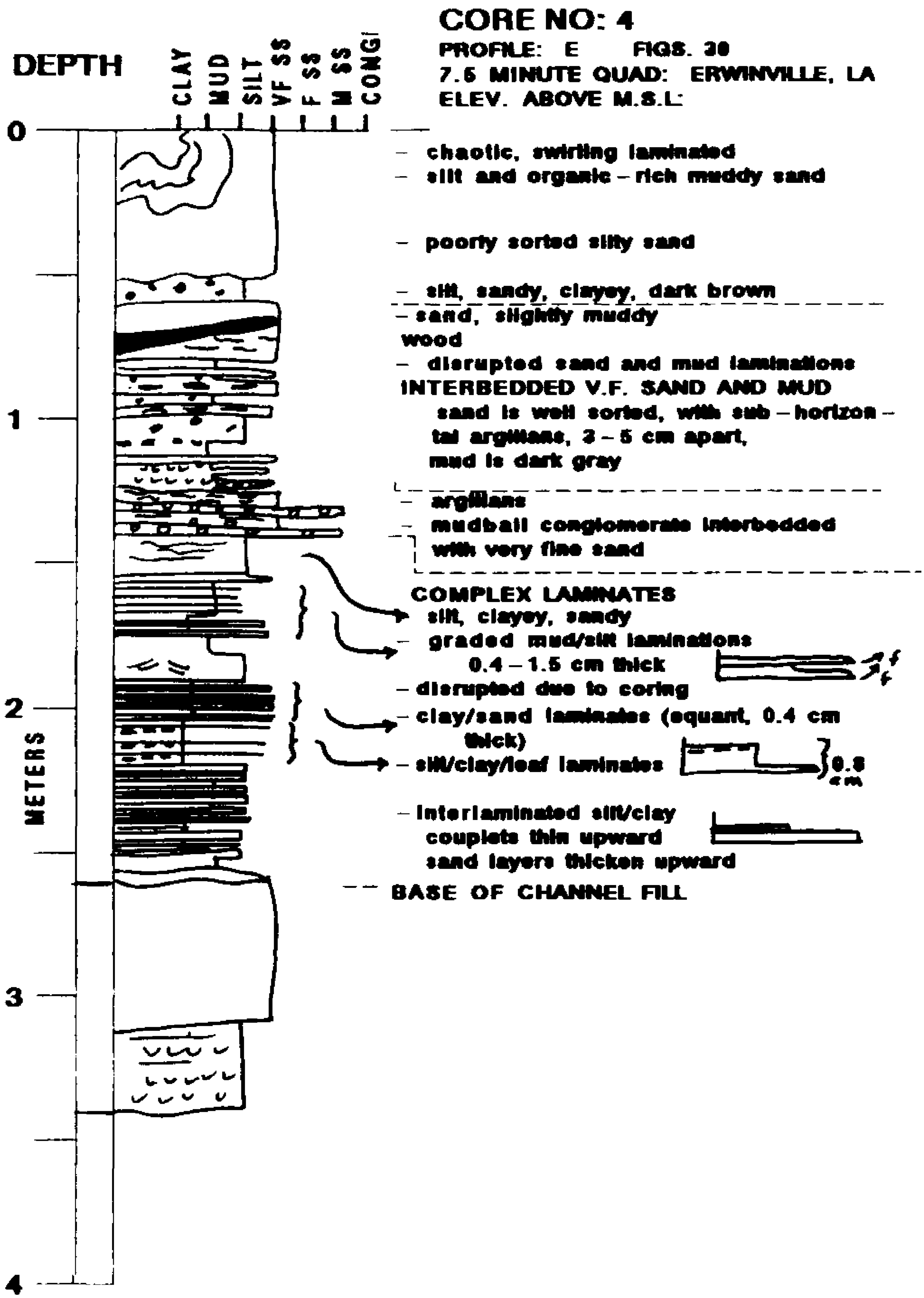
CORE NO: 1

PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 23 FT

- very fine muddy sand, yellowish brown (channel fill)
- FB4: silty clay, bluish gray w/orange mottling
- silty, clay dark brown, pelletal with granular Fe – oxides
- FB7: silt, pelletal, sandy, dark brown with granular Fe – oxides

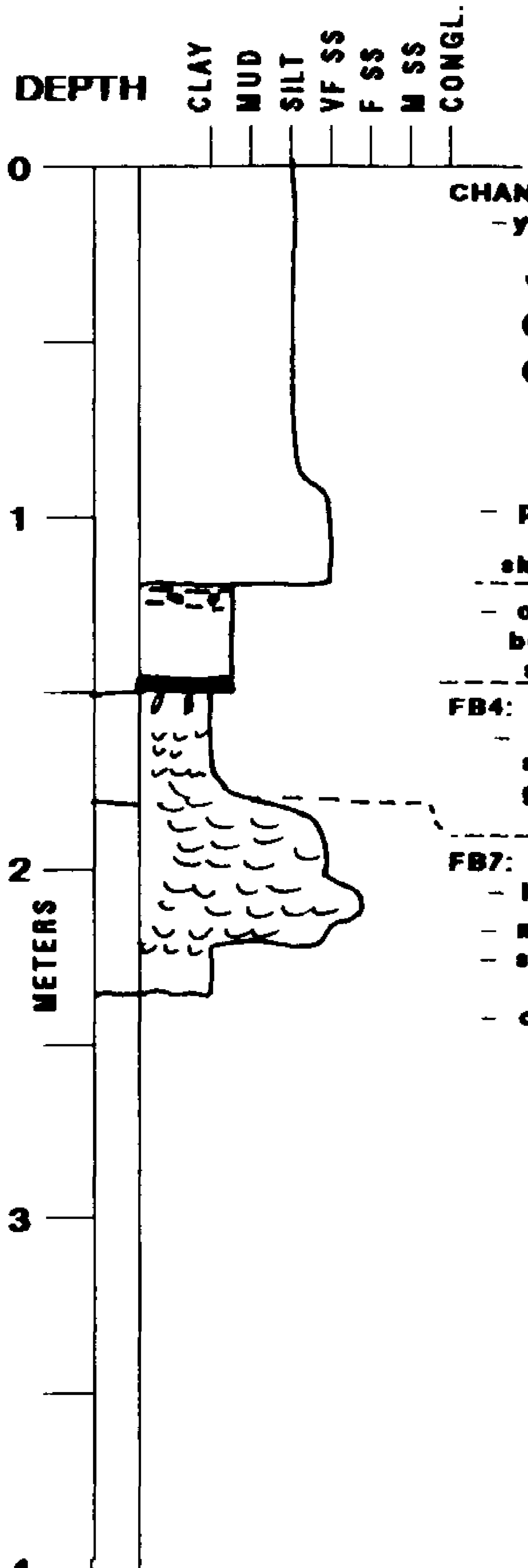

CORE NO: 2
PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 24
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
1
2
3
4
METERS
– very fine silty and muddy sand
yellow, less than 10% clay
no concretionary material
– hard, clayey, sandy silt, yellow
mottles of clayey sand, detrital organics
– clay, detrital organics, clay/silt lams
BASE OF CHANNEL FILL
– FB4: clay, gray with orange mottling
minor bedded organics
– pelletal sandy mud
FB7
– very fine muddy sand, yellow, pelletal
dark gray patches (clay and organics
with pelletal texture in large burrows)
– gray, hard, pelletal mud
sand content increases downward
– intensively burrowed pelletal sand
Fe – oxide concretions (0.5X0.75 cm)
disjointed clay layer
sandy pelletal mud


CORE NO: 3
PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 24 FT
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
1
2
3
4
METERS
– fine – med sand, well – sorted, white
– FB4: sandy clay or mud, brown, pelletal
– FB7: brown, muddy pelletal sand with granular Fe – oxides
extensively pelletal and burrowed silt
brown pelletal mud
dark grayish – brown clay and mud


CORE NO: 4
PROFILE: E FIGS. 30
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L:
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGl
0
1
2
3
4
METERS
– chaotic, swirling laminated
– silt and organic – rich muddy sand
– poorly sorted silty sand
– silt, sandy, clayey, dark brown
– sand, slightly muddy
wood
– disrupted sand and mud laminations
INTERBEDDED V.F. SAND AND MUD
sand is well sorted, with sub – horizon – tal argillans, 3 – 5 cm apart,
mud is dark gray
– argillans
– mudball conglomerate interbedded with very fine sand
COMPLEX LAMINATES
silt, clayey, sandy
– graded mud/silt laminations 0.4 – 1.5 cm thick
f
f
– disrupted due to coring
– clay/sand laminates (equant, 0.4 cm thick)
– silt/clay/leaf laminates
0.8 cm
– interlaminated silt/clay couplets thin upward sand layers thicken upward
BASE OF CHANNEL FILL

CORE NO: 5

PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 25 FT



CHANNEL FILL:

- yellowish brown, slightly clayey, very very fine sandy silt and silty sand, very soft, micaceous

(root hairs)

(wood fragments)

- possible rip – up clasts

sharp basal contact

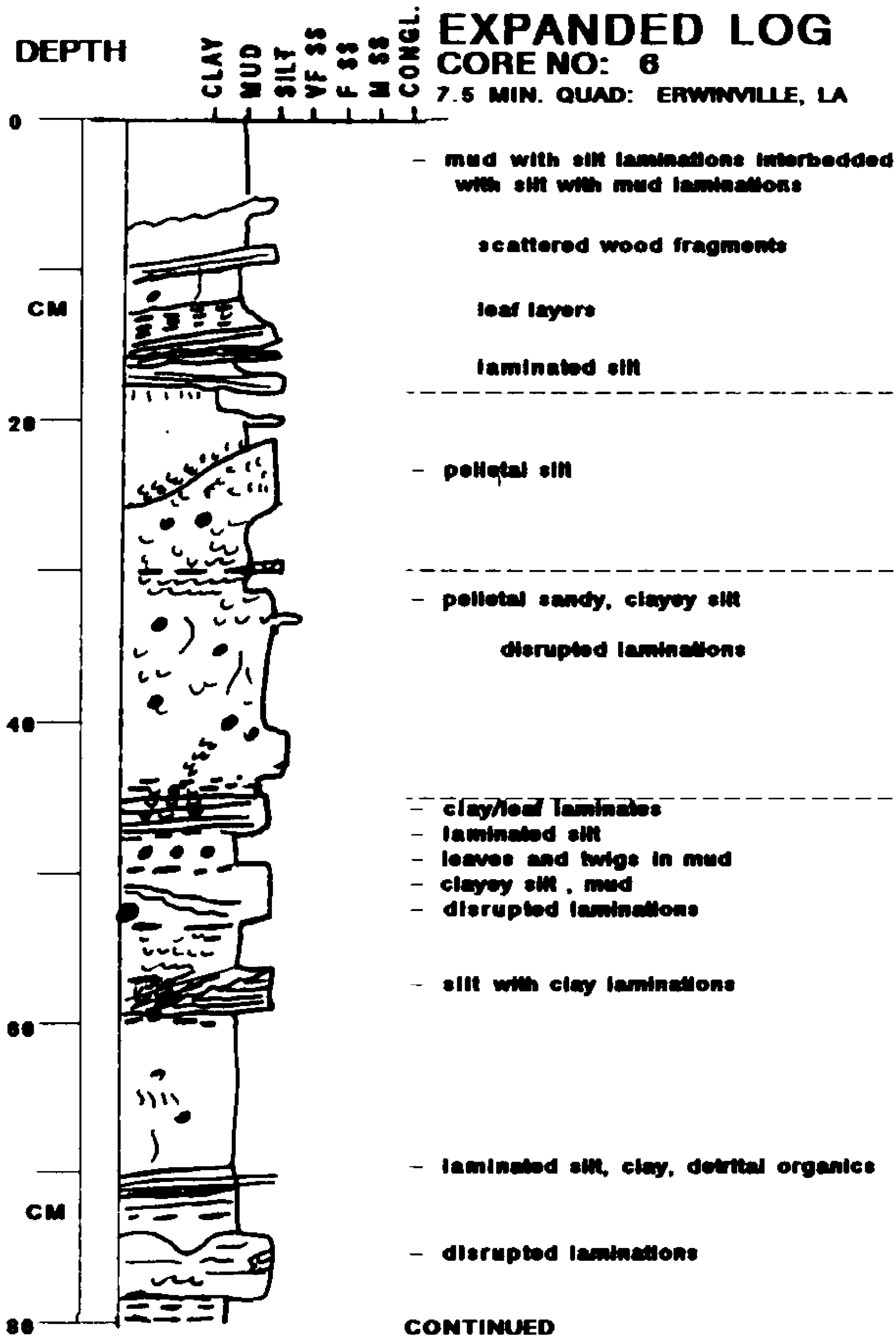
- organic – rich mud and silty clay bedded organics, twigs and leaf stacks, as indicated; wood at base

FB4:

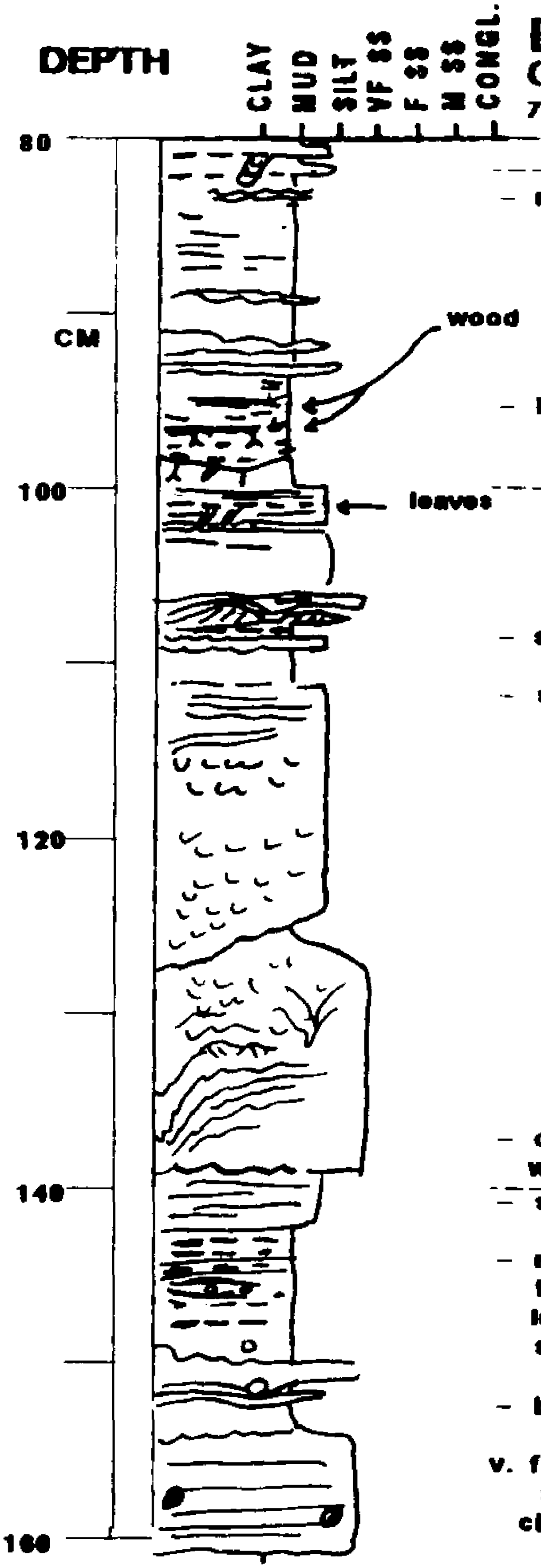
- gray clay with disseminated organics sharp upper contact gradational, mottled lower contact

FB7:

- hard, clayey sand, very silty
- moderately sorted fine sand
- silty very fine sand
- clay, with granular Fe – oxides


EXPANDED LOG
CORE NO: 6
7.5 MIN. QUAD: ERWINVILLE, LA
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
CM
20
40
60
CM
80
- mud with silt laminations interbedded with silt with mud laminations
scattered wood fragments
leaf layers
laminated silt
- pelletal silt
- pelletal sandy, clayey silt
disrupted laminations
- clay/leaf laminates
- laminated silt
- leaves and twigs in mud
- clayey silt , mud
- disrupted laminations
- silt with clay laminations
- laminated silt, clay, detrital organics
- disrupted laminations
CONTINUED

EXPANDED LOG
CORE NO: 6
7.5 MIN. QUAD: ERWINVILLE, LA



- mud with erratic silt layers

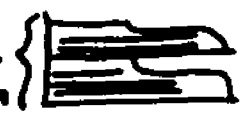
- leaf and organic debris mats
  flat lying wood, discontinuous
  blebs of coffee grounds

- clay laminations, 0.1 mm thick

- starved ripples

- squigly laminations, not flat
  like above

- disrupted v.f. sand
  with clay laminations 4 cm



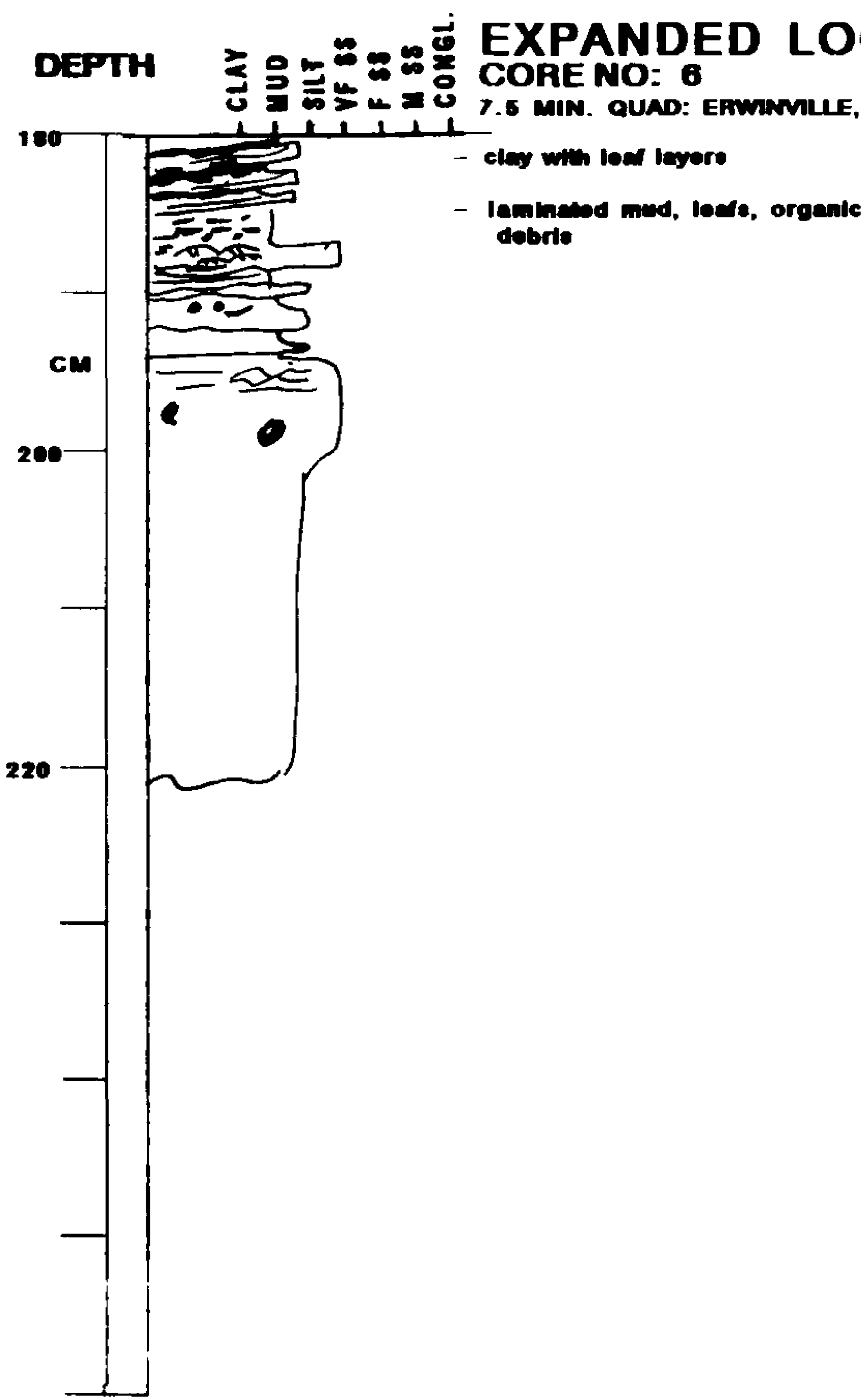
- silt with mud laminations

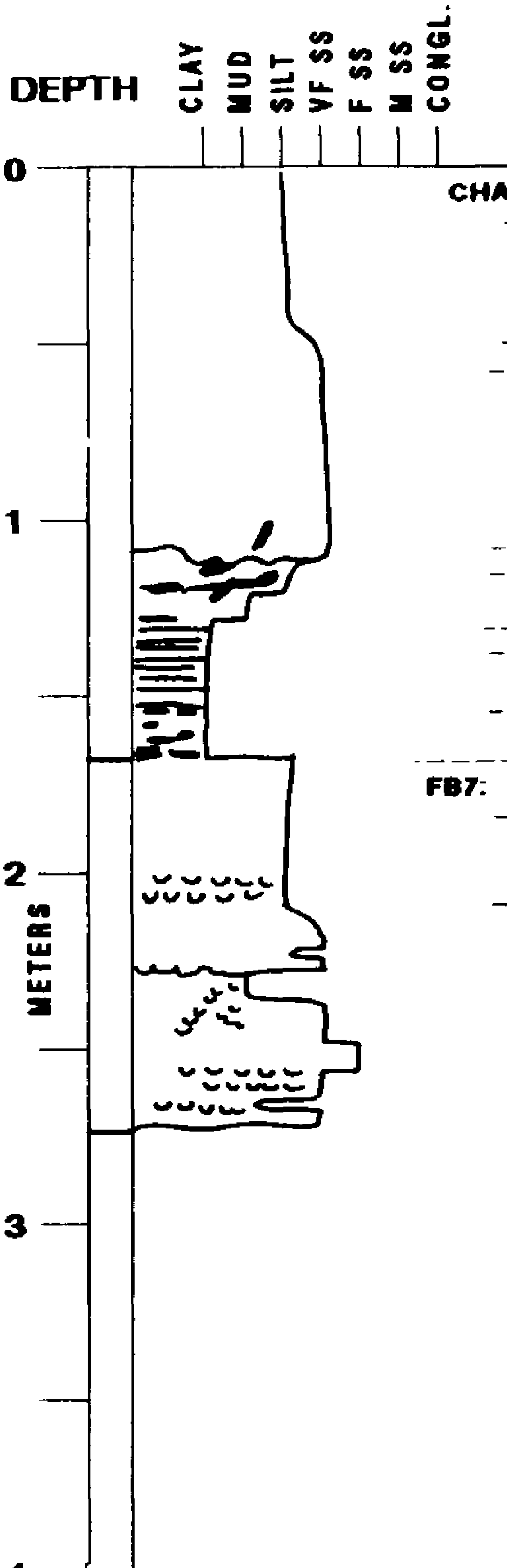
- mud with wavy silt laminations
  twigs
  leaf layers
  silt layers above leaf layers

- bent laminations

v. f. sand with clay laminations
ss lams = 0.5 cm thick
clay layers, discontinuous, with
irregular thickness CONTINUED

EXPANDED LOG
CORE NO: 6
7.5 MIN. QUAD: ERWINVILLE, LA





CORE NO: 7

PROFILE: none

7.5 MINUTE QUAD: ERWINVILLE, LA

ELEV. ABOVE M.S.L: 25 FT

CHANNEL FILL:

- sandy, clayey silt, hard, structureless, looks like road fill, light brown

---

- hard, slightly clayey silty sand ROAD FILL

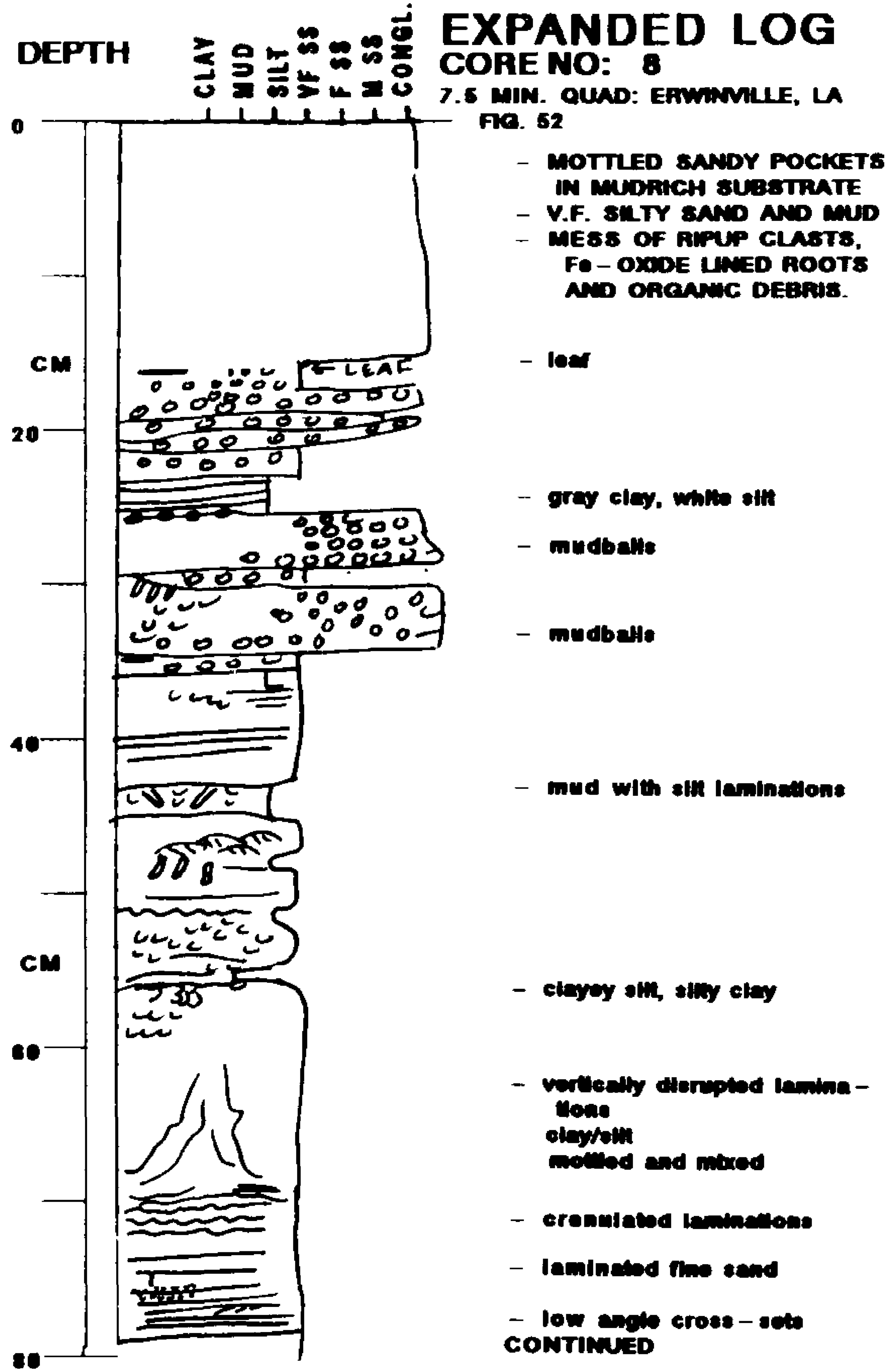
- overcompaction, wood fragments
- micaseous sandy mud with dissem. organics bedded wood

- clay/leaf laminates, brownish gray local wood horizons, leaf stacks
- discontinuous laminae of detrital organics (lenticular bedding)

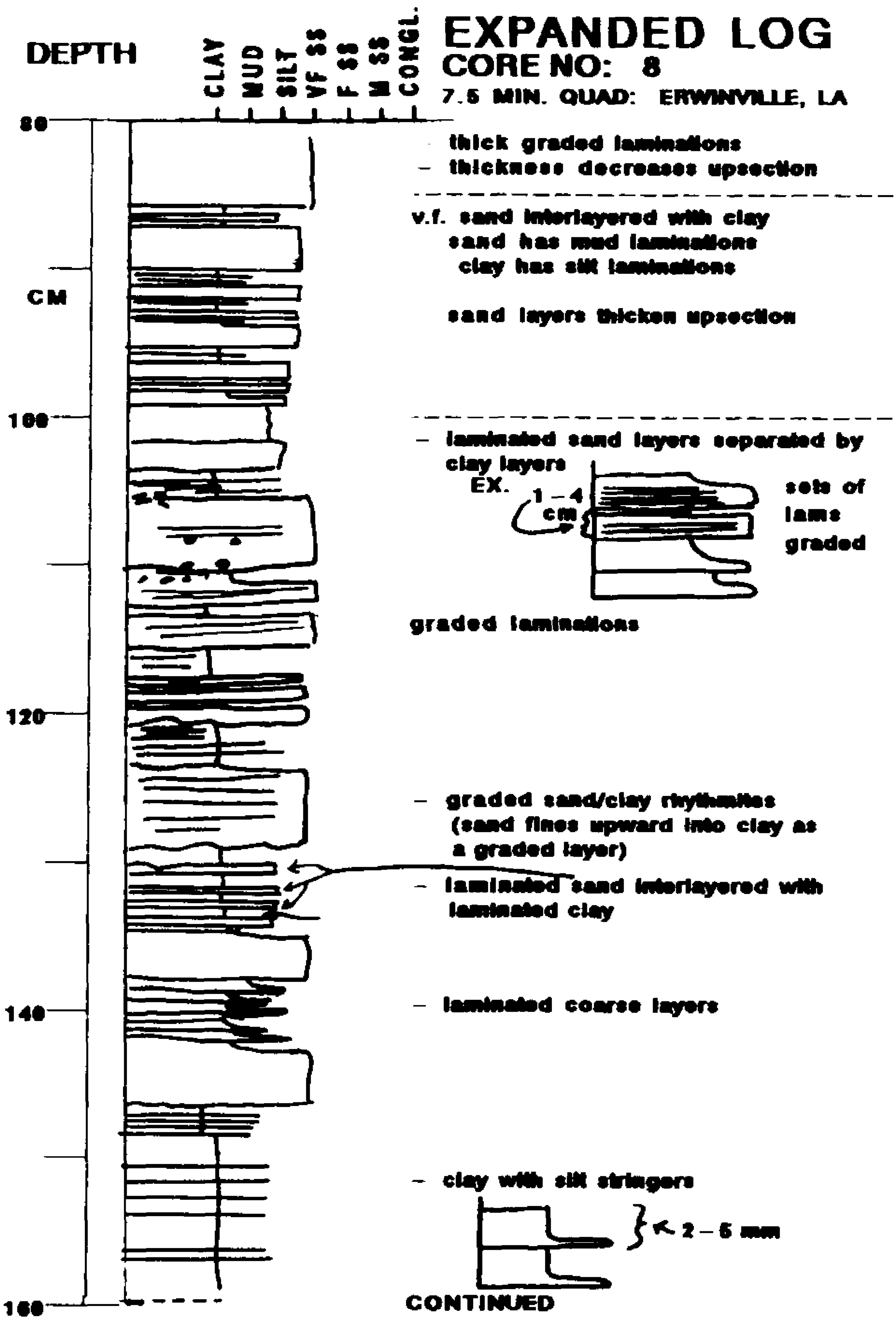
FB7:

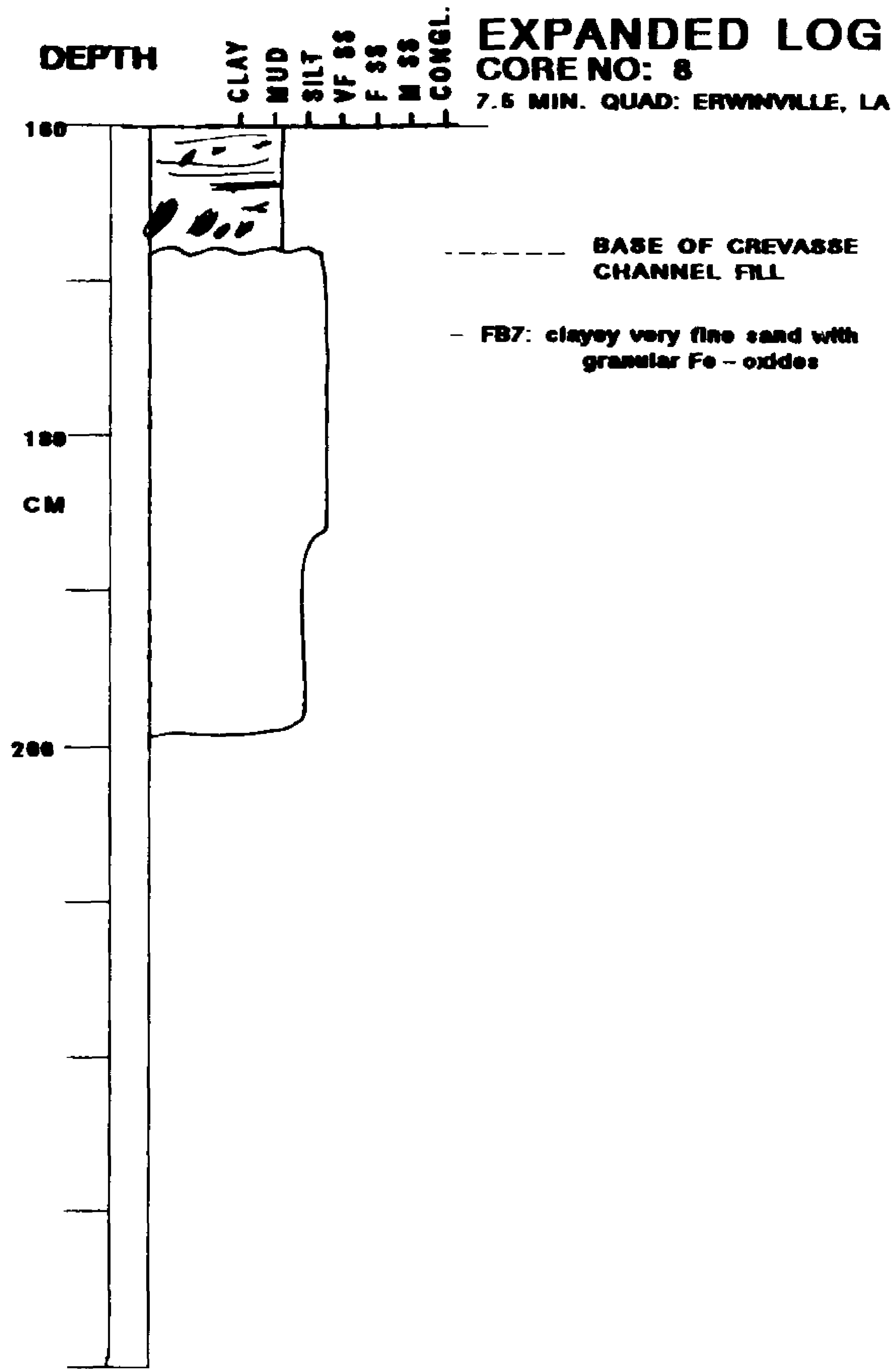
- micaceous, sandy, clayey silt, olive gray to pale blue

- pelletal sandy silt, trace of clay



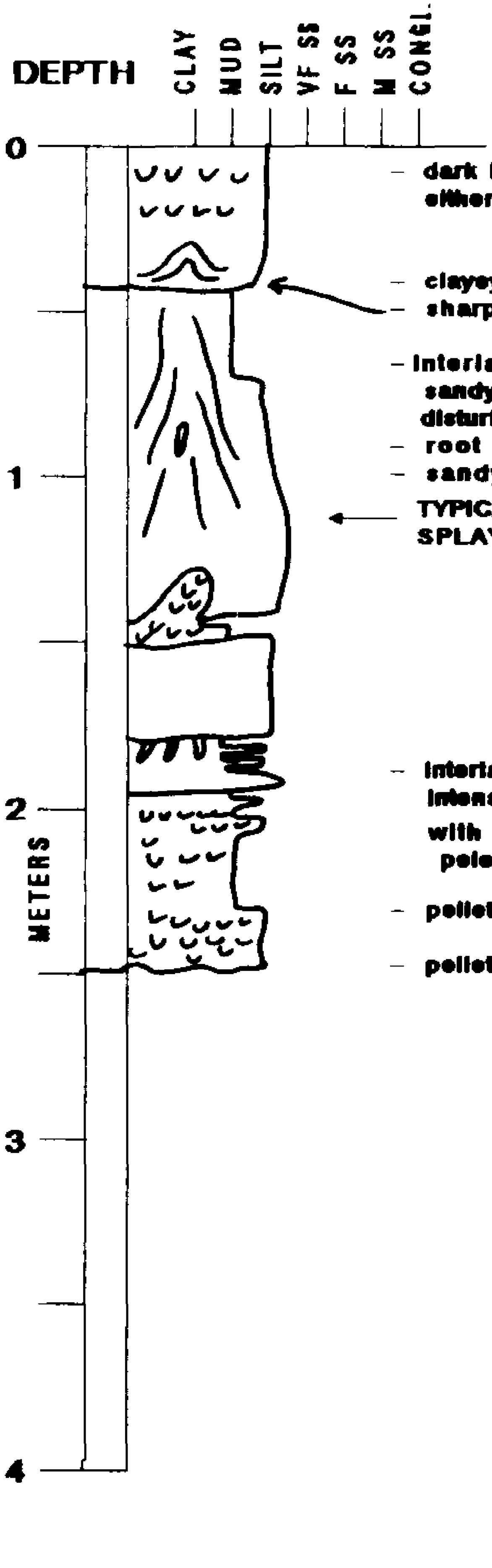
EXPANDED LOG
CORE NO: 8
7.5 MIN. QUAD: ERWINVILLE, LA
FIG. 52
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
CM
20
40
CM
60
80
LEAF
– MOTTLED SANDY POCKETS IN MUDRICH SUBSTRATE
– V.F. SILTY SAND AND MUD
– MESS OF RIPUP CLASTS, Fe – OXIDE LINED ROOTS AND ORGANIC DEBRIS.
– leaf
– gray clay, white silt
– mudballs
– mudballs
– mud with silt laminations
– clayey silt, silty clay
– vertically disrupted laminations
clay/silt
mottled and mixed
– crenulated laminations
– laminated fine sand
– low angle cross – sets
CONTINUED


EXPANDED LOG
CORE NO: 8
7.5 MIN. QUAD: ERWINVILLE, LA
DEPTH
CM
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
80
100
120
140
160
- thick graded laminations
- thickness decreases upsection
v.f. sand interlayered with clay
sand has mud laminations
clay has silt laminations
sand layers thicken upsection
- laminated sand layers separated by clay layers
EX.
1 - 4 cm
sets of lams graded
graded laminations
- graded sand/clay rhythmites (sand fines upward into clay as a graded layer)
- laminated sand interlayered with laminated clay
- laminated coarse layers
- clay with silt stringers
2 - 5 mm
CONTINUED


DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
EXPANDED LOG
CORE NO: 8
7.5 MIN. QUAD: ERWINVILLE, LA
160
180
CM
200
BASE OF CREVASSE CHANNEL FILL
FB7: clayey very fine sand with granular Fe – oxides

CORE NO: 10

PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 24 FT

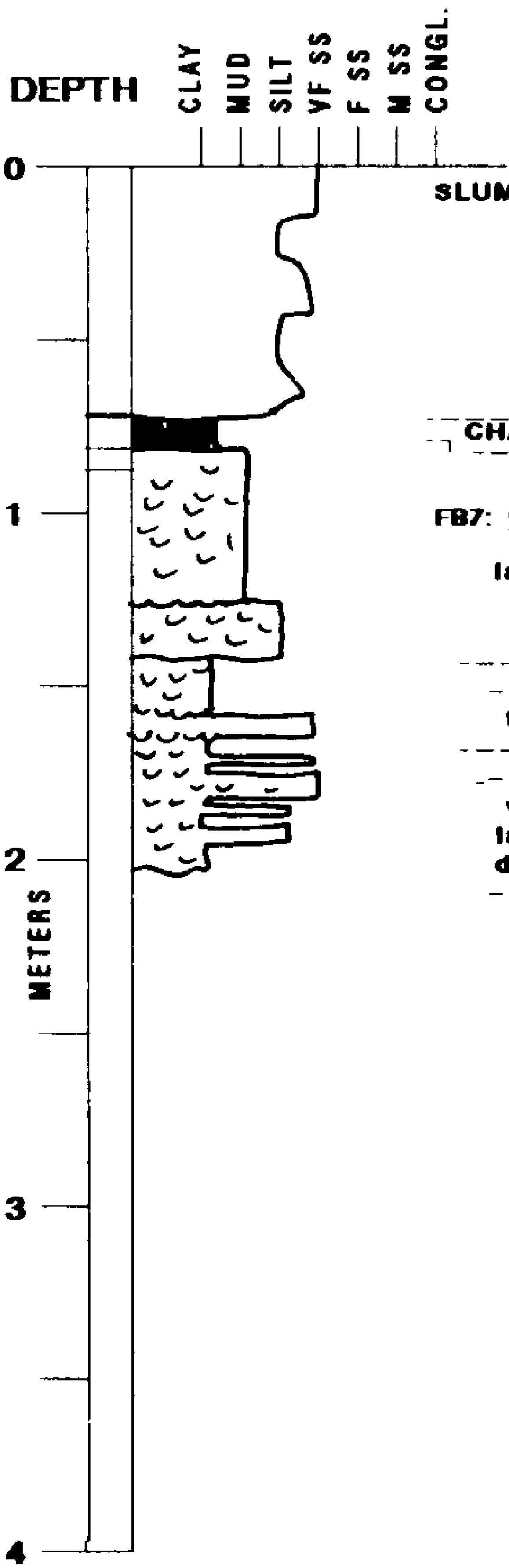


- dark brown organic – rich clayey silt either pelletal or contains clastic silt balls
- clayey silt with trace of swirling laminations
- sharp contact
- interlaminated pelletal mud, silty sand and sandy silt with swirling laminations due to disturbance by vibracoring
- root hairs with Fe – oxide linings
- sandy silt and silty sand

TYPICAL PELLETAL SILT OF LEVEE AND SPLAY LOBES

- interlayered pelletal silt and pelletal mud. intensively burrowed with granular Fe – oxides associated with peleital fabric
- pelletal mud
- pelletal silt

CORE NO: 12
PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 24 ft



SLUMP OR FILL DIRT

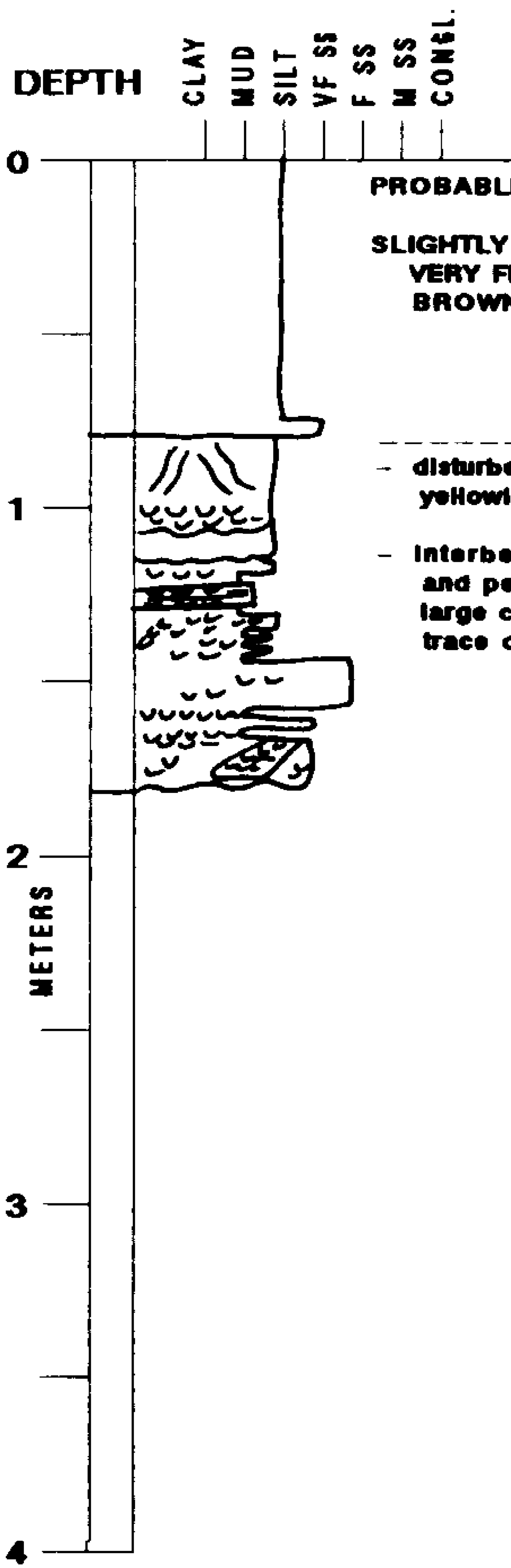
mixed mud and very fine sand

CHANNEL FILL: PEAT

FB7: yellow, pelletal clayey silt with silt – rich matrix
swirling laminations
lacking granular Fe – oxides

– interbedded brownish – gray pelletal clay and tan very fine pelletal sand

– interbedded pelletal clay andd pelletal very fine well – sorted sand, locally with distorted laminations, leaf fragments and organic debris
– Fe – oxides as coatings on root hairs only in mud layers



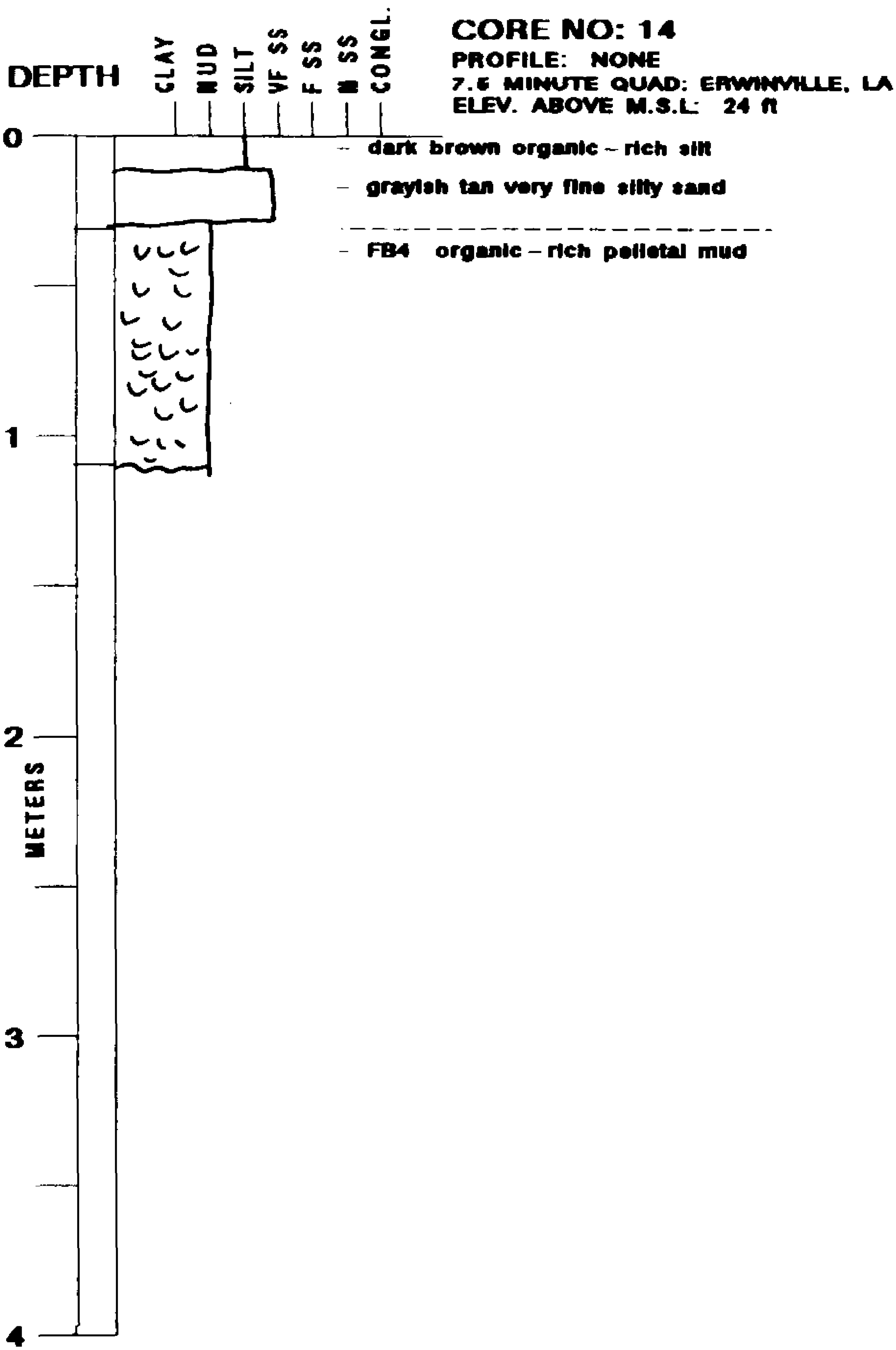
CORE NO: 13
PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 24 ft

PROBABLE FILL DIRT

SLIGHTLY CLAYEY, SILTY
VERY FINE SAND,
BROWNISH YELLOW

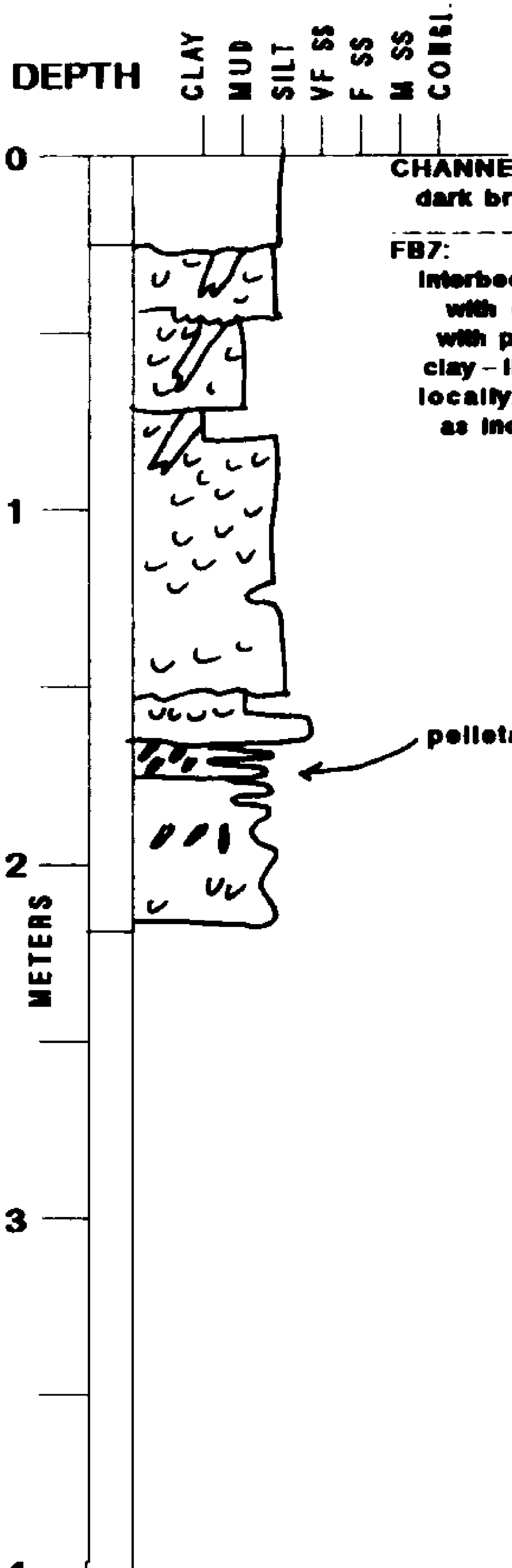
- disturbed silty very fine sand and sandy silt yellowish, probably pelletal

- interbedded pelletal mud, pelleal silty sand and pelletal sandy silt
large cross – cutting burrows,
trace of laminations where indicated


CORE NO: 14
PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 24 ft
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
1
2
3
4
METERS
dark brown organic – rich silt
grayish tan very fine silty sand
FB4 organic – rich pelletal mud

CORE NO: 15

PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 24 ft

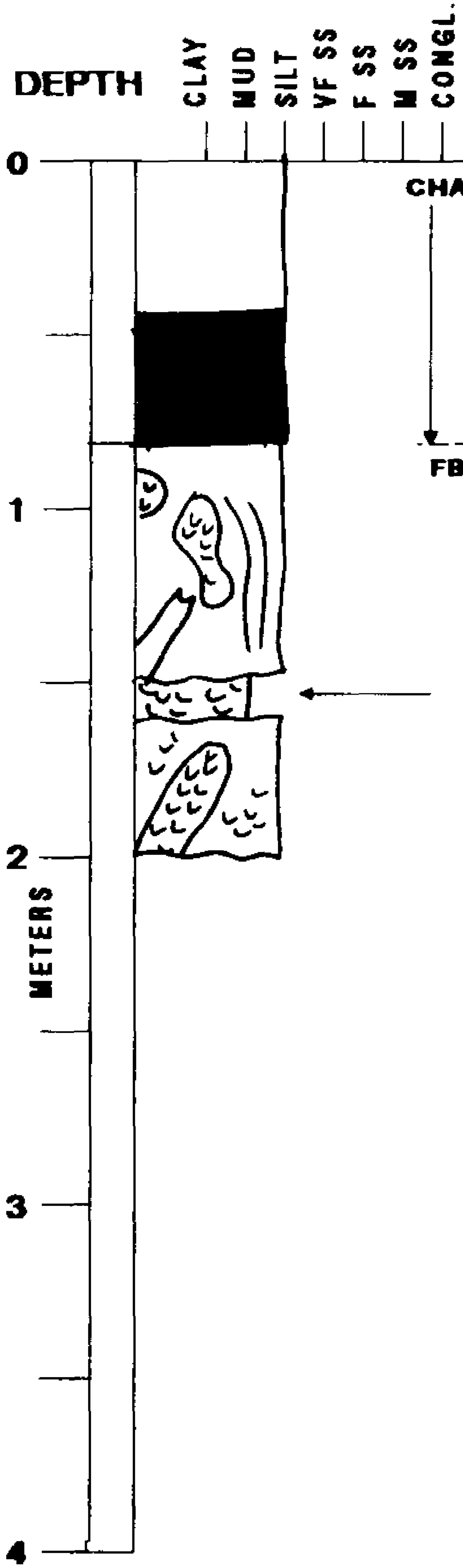


CHANNEL FILL:
dark brown organic – rich silt

FB7:
interbedded pelletal silt and clay with granular Fe – oxides associated with pelletal fabric.
clay – lined root burrow
locally, rootlets have Fe – oxide linings as indicated.

pelletal mud with silt laminations

CORE NO: 16
PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L:



CHANNEL FILL

FILL: yellow silt with organic debris

dark brown organic – rich silt, peaty with wood

FB7: distorted pelletal silt with trace of swirling laminations

- **root burrows with clay linings or fillings**
- **large cross – cutting burrows with pelletal internal fill**
- **trace of Fe – oxides**

– **pelletal organic – rich mud**

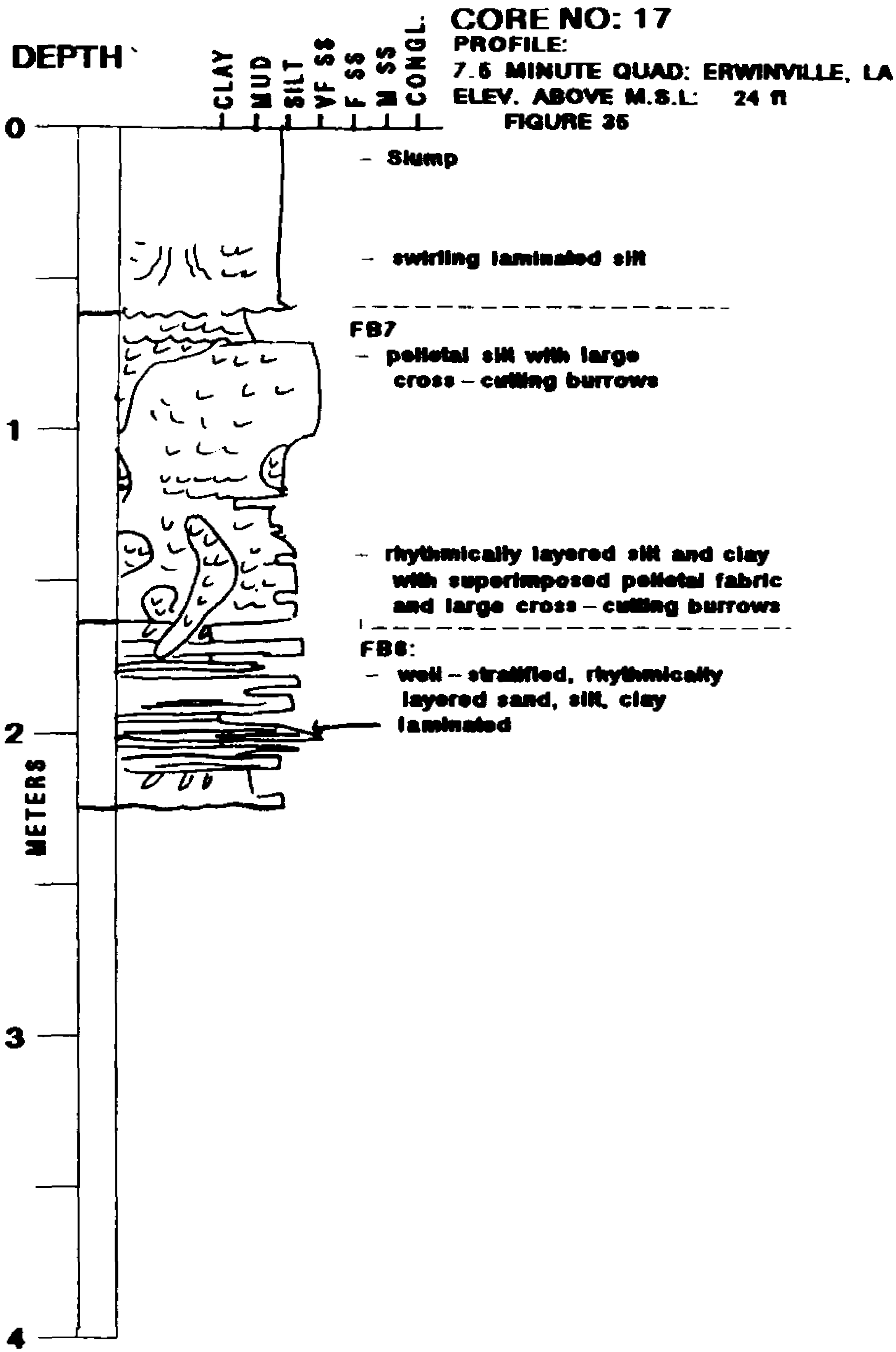

CORE NO: 17
PROFILE:
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 24 ft
DEPTH
METERS
0
1
2
3
4
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
- Slump
- swirling laminated silt
FB7
- pelletal silt with large cross - cutting burrows
- rhythmically layered silt and clay with superimposed pelletal fabric and large cross - cutting burrows
FB8:
- well - stratified, rhythmically layered sand, silt, clay
laminated

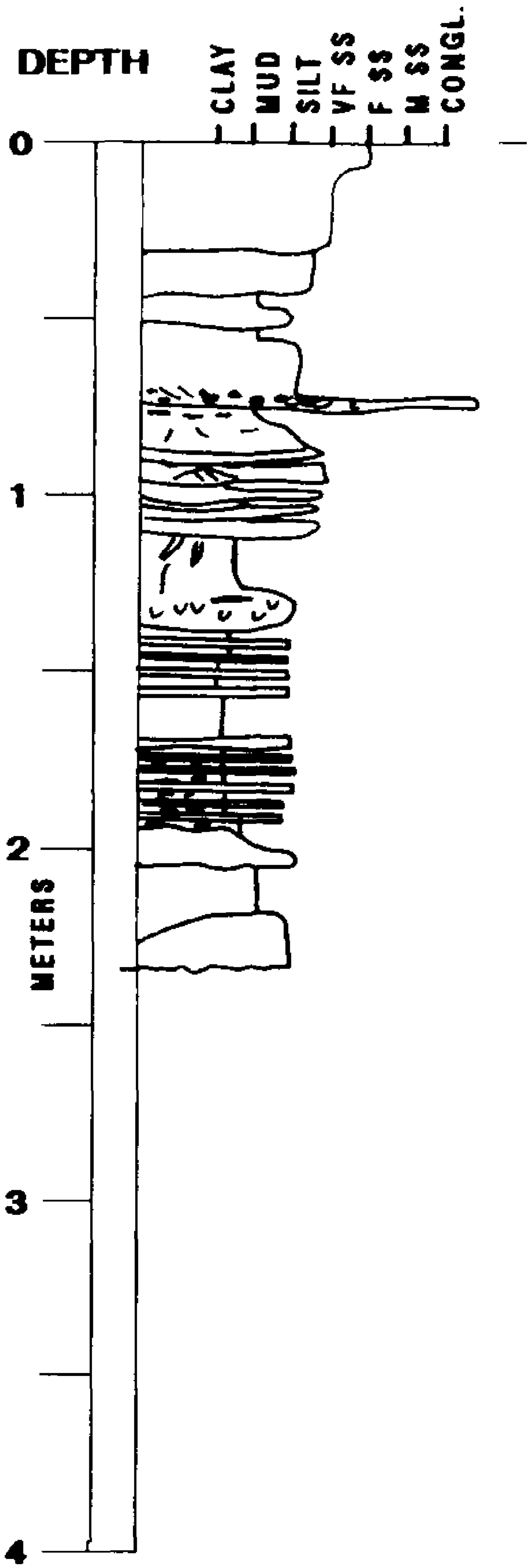
FIGURE 35

CORE NO: 18

PROFILE: E

7.5 MINUTE QUAD: ERWINVILLE,LA

ELEV. ABOVE M.S.L: 24 FT



- SEE EXPANDED LOG ON NEXT PAGE FOR DETAILS ON THIS CORE

- Complex laminates

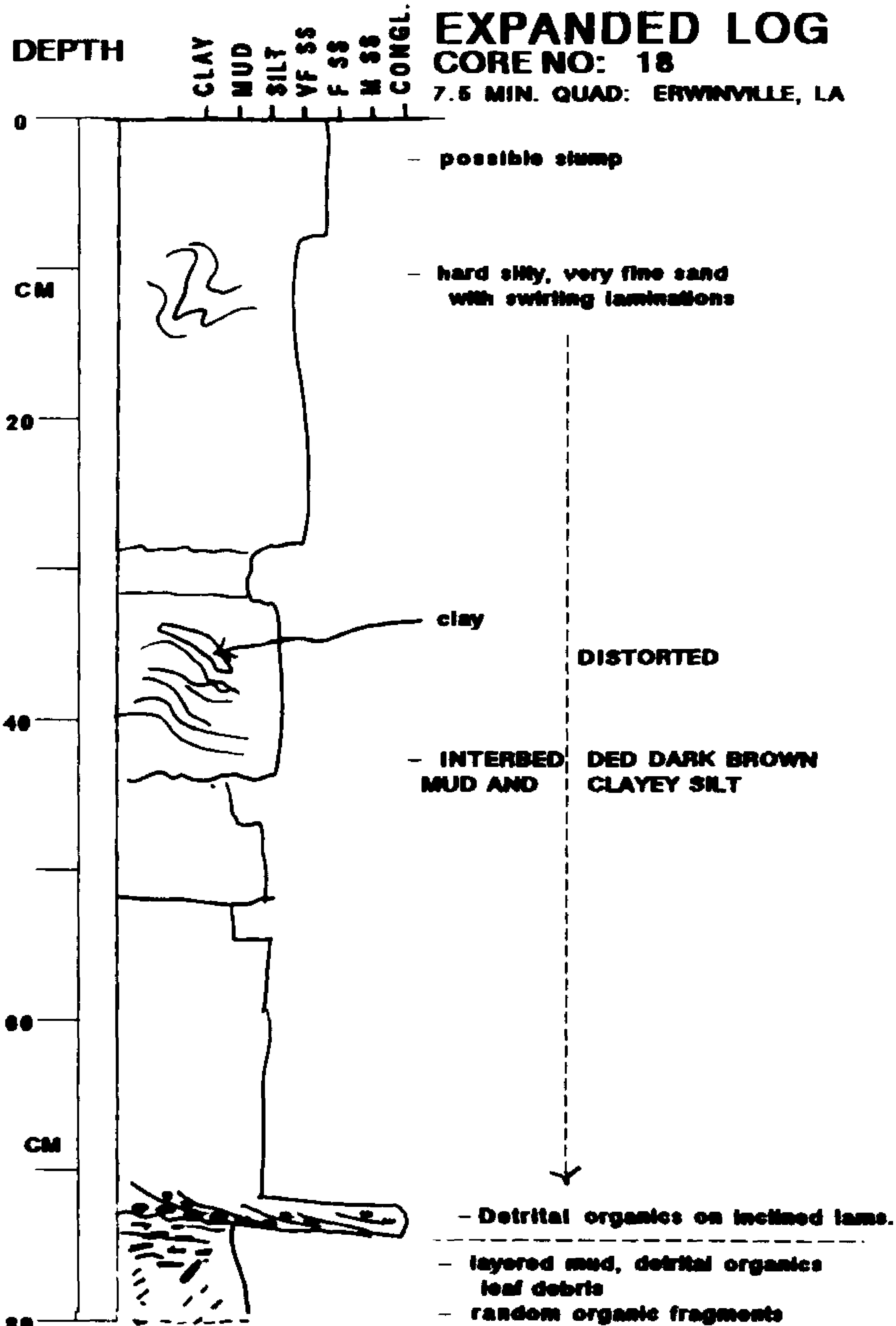
BASE OF CHANNEL FILL

FB7

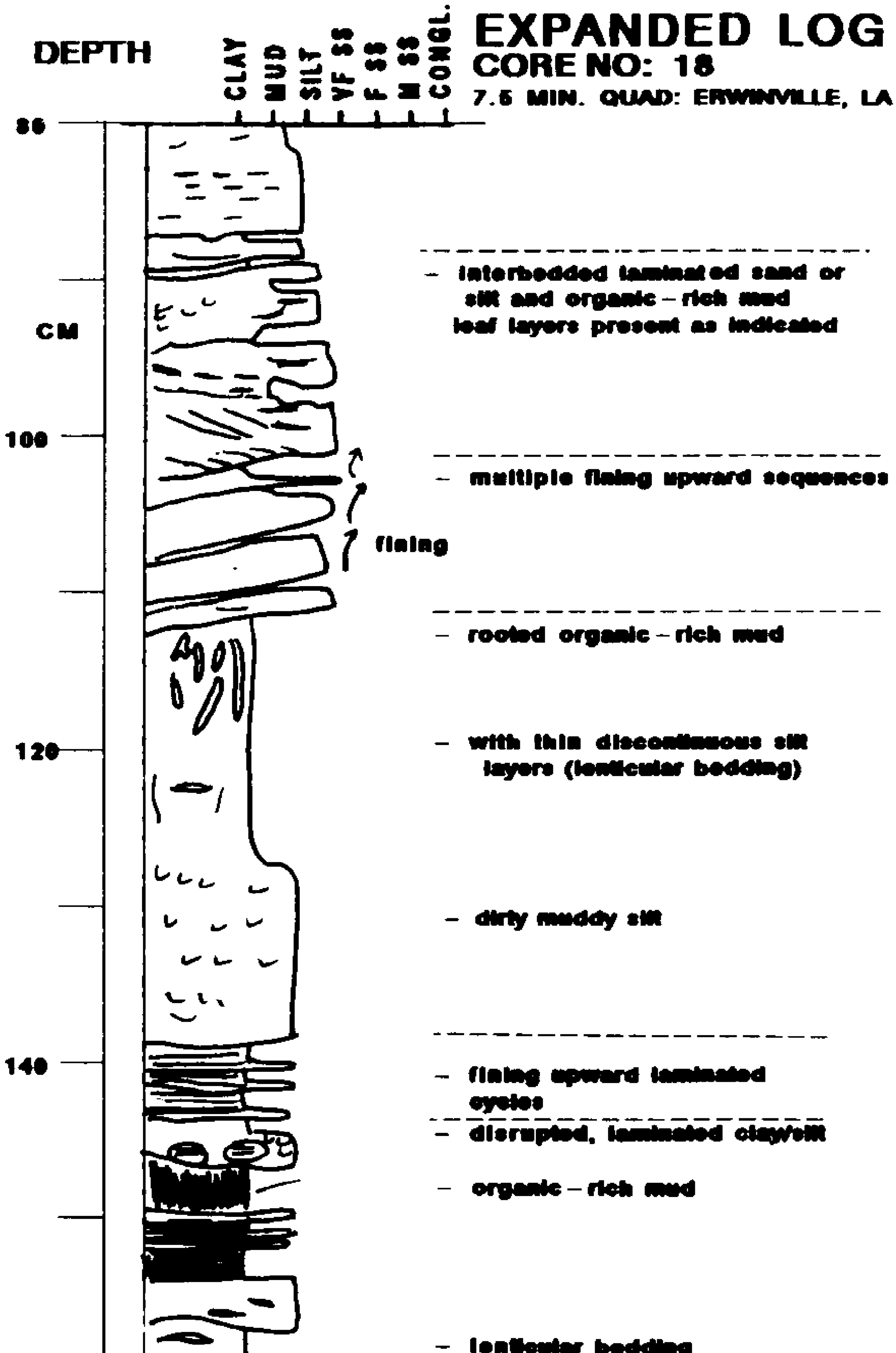
EXPANDED LOG

CORE NO: 18

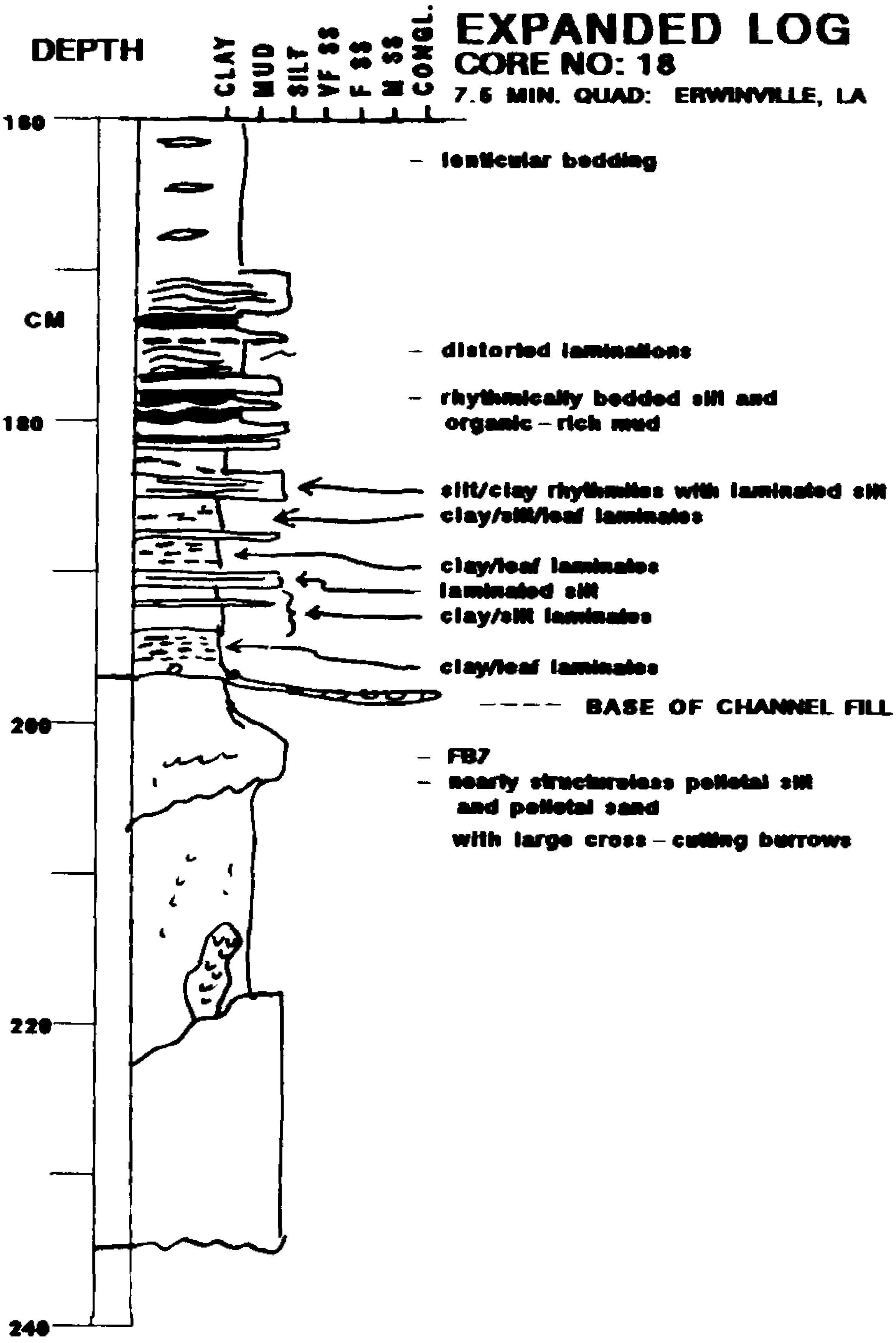
7.5 MIN. QUAD: ERWINVILLE, LA

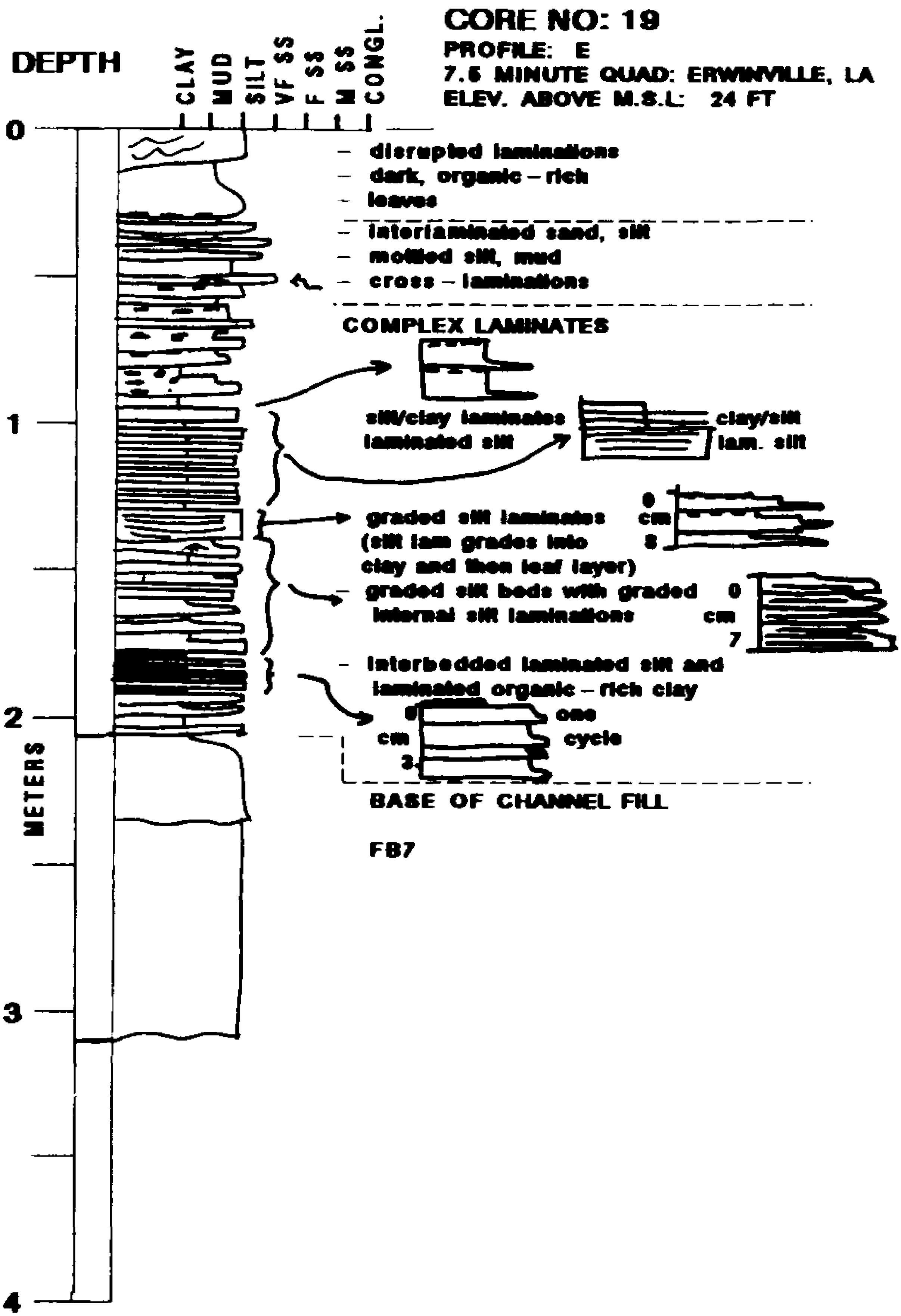


CONTINUED ON NEXT PAGE



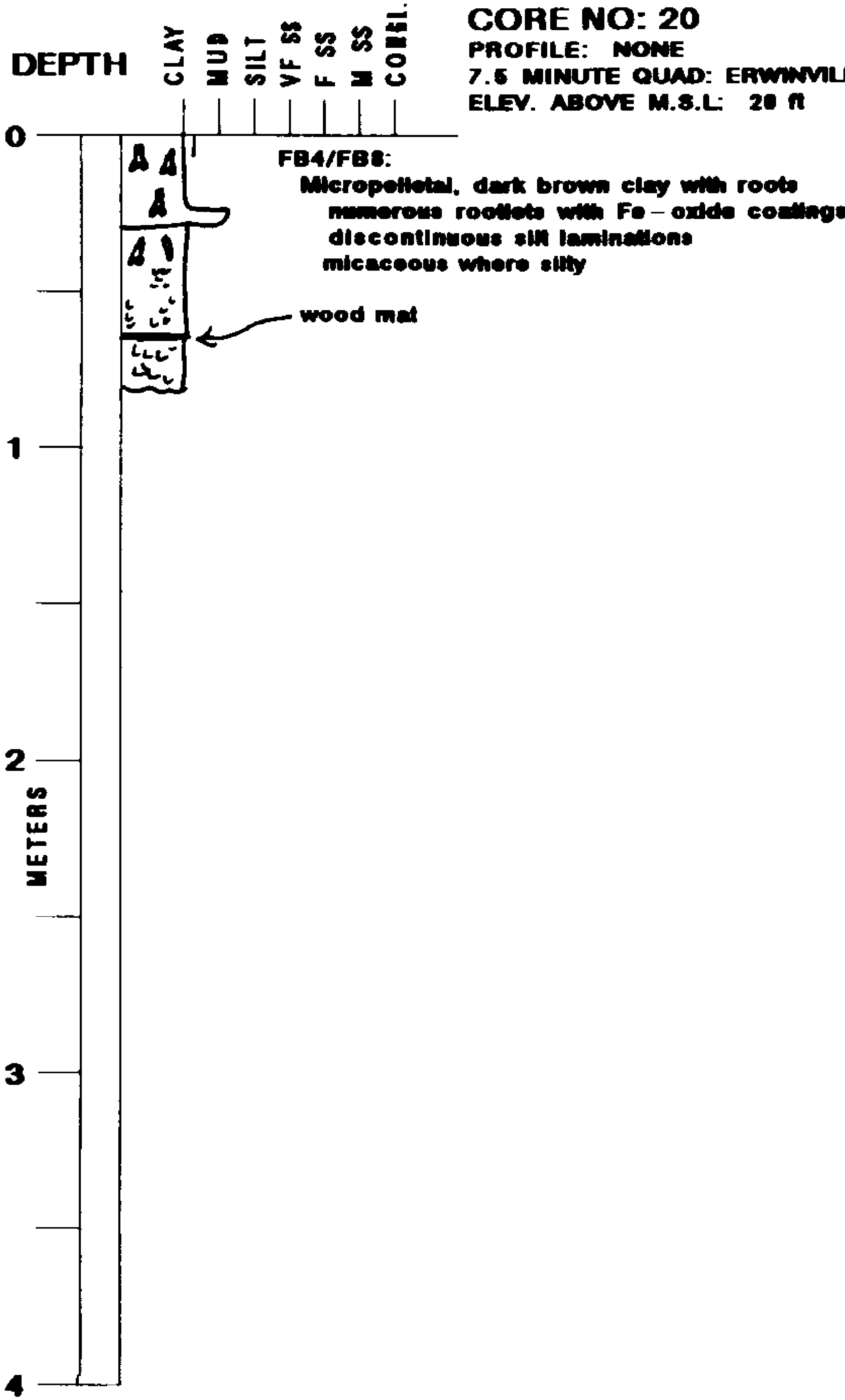
CONTINUED ON NEXT PAGE

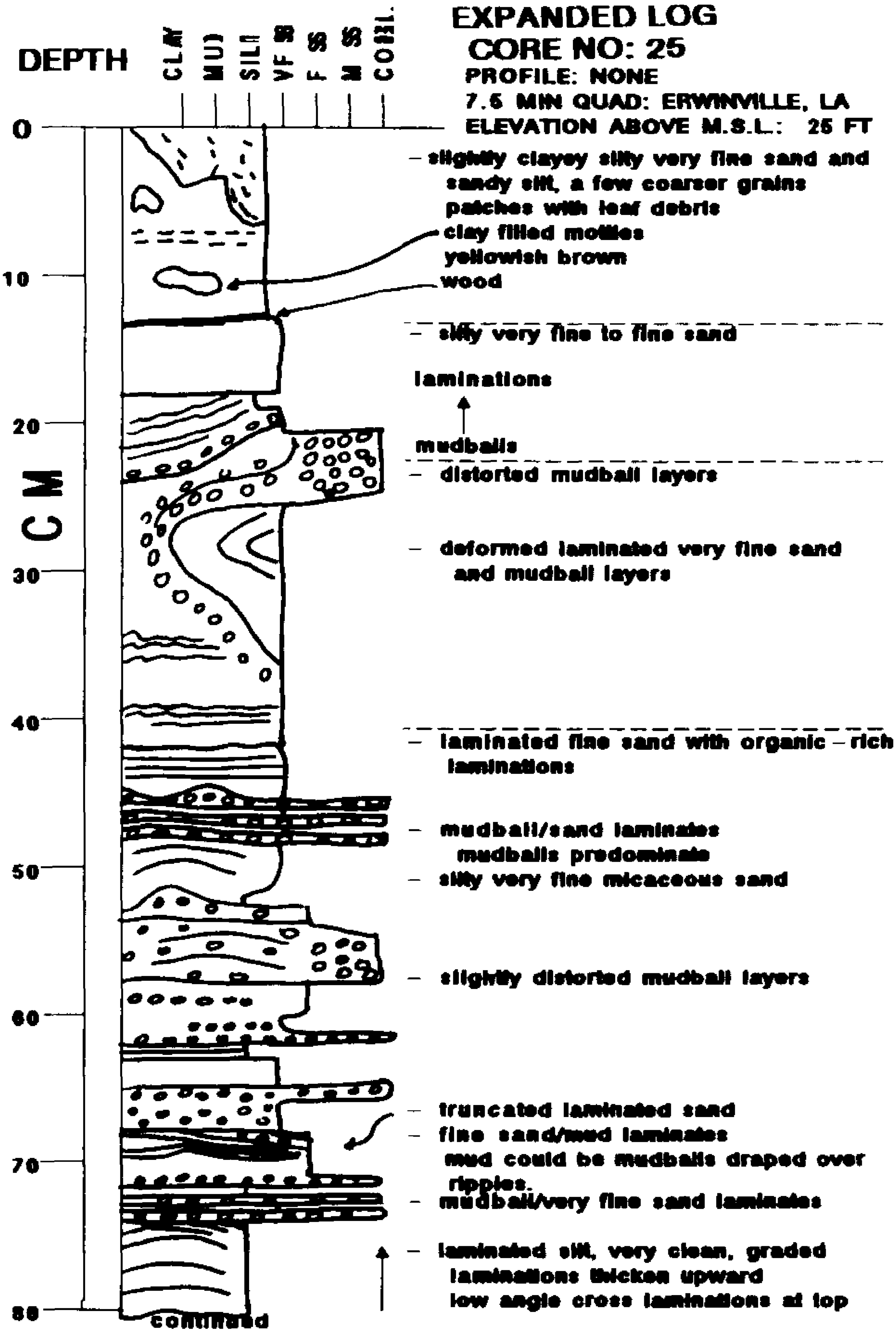

DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
EXPANDED LOG
CORE NO: 18
7.5 MIN. QUAD: ERWINVILLE, LA
160
CM
180
200
220
240
- lenticular bedding
- distorted laminations
- rhythmically bedded silt and organic-rich mud
silt/clay rhythmites with laminated silt
clay/silt/leaf laminates
clay/leaf laminates
laminated silt
clay/silt laminates
clay/leaf laminates
BASE OF CHANNEL FILL
- FB7
- nearly structureless pelletal silt and pelletal sand with large cross-cutting burrows


CORE NO: 19
PROFILE: E
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 24 FT
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
1
2
3
4
METERS
- disrupted laminations
- dark, organic - rich
- leaves
- interlaminated sand, silt
- mottled silt, mud
- cross - laminations
COMPLEX LAMINATES
silt/clay laminates
laminated silt
clay/silt
lam. silt
graded silt laminates
(silt lam grades into
clay and then leaf layer)
0
cm
8
- graded silt beds with graded
internal silt laminations
0
cm
7
- interbedded laminated silt and
laminated organic - rich clay
0
cm
3
one
cycle
BASE OF CHANNEL FILL
FB7

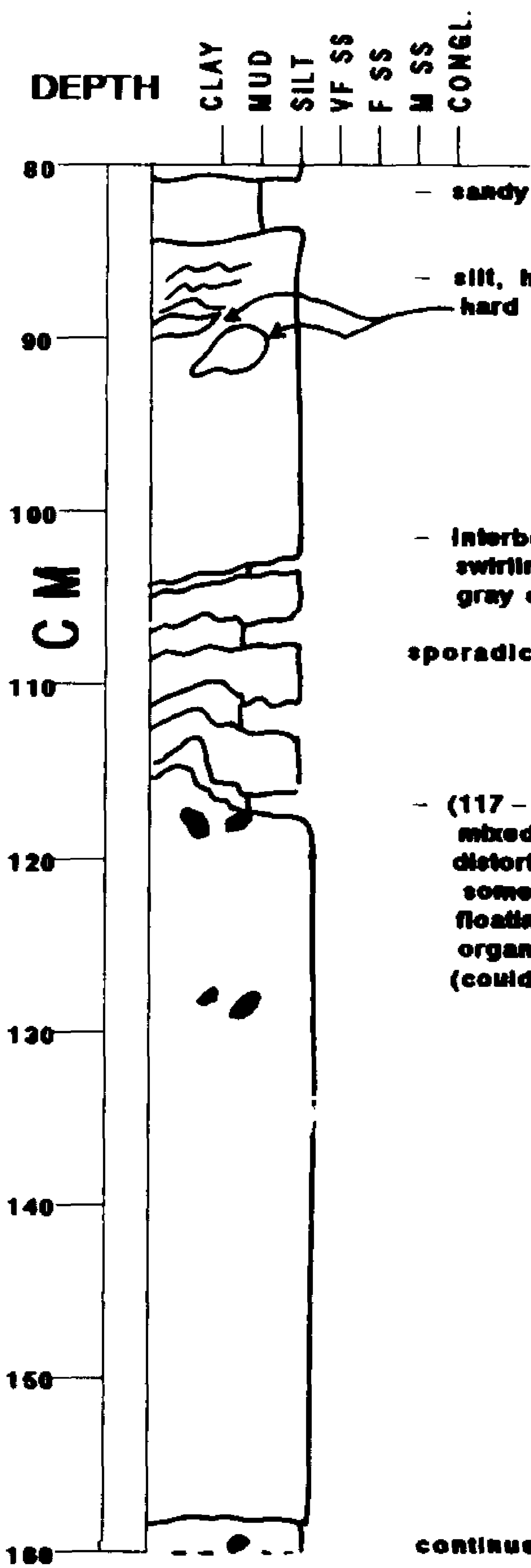
CORE NO: 20

PROFILE: NONE
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 20 ft




EXPANDED LOG
CORE NO: 25
PROFILE: NONE
7.5 MIN QUAD: ERWINVILLE, LA
ELEVATION ABOVE M.S.L.: 25 FT
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
COBL.
C M
0
10
20
30
40
50
60
70
80
- slightly clayey silty very fine sand and sandy silt, a few coarser grains
patches with leaf debris
clay filled mottles
yellowish brown
wood
- silty very fine to fine sand
laminations
mudballs
- distorted mudball layers
- deformed laminated very fine sand and mudball layers
- laminated fine sand with organic - rich laminations
- mudball/sand laminates
mudballs predominate
- silty very fine micaceous sand
- slightly distorted mudball layers
- truncated laminated sand
- fine sand/mud laminates
mud could be mudballs draped over ripples.
- mudball/very fine sand laminates
- laminated silt, very clean, graded
laminations thicken upward
low angle cross laminations at top
continued

EXPANDED LOG
CORE NO: 25 continued
PROFILE: NONE
7.5 MIN QUAD: ERWINVILLE, LA



– sandy mud or muddy sand

– silt, hard clayey, swirling laminations
hard gray clay, Fe – oxide inclusions

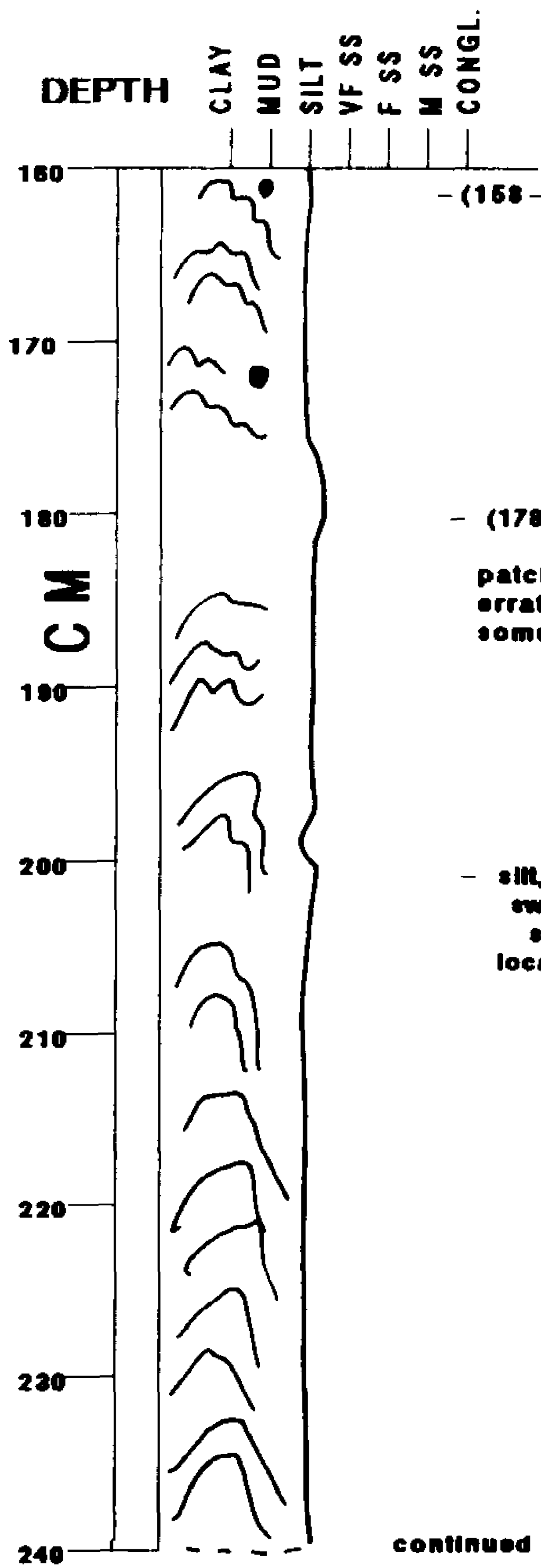
– interbedded clay and silt
swirling, hard
gray clay with Fe – oxides

sporadic wood as indicated

– (117 – 158 cm)
mixed sediment
distorted
some laminations
floating muddy balls
organic – rich patches
(could be fill)

continued on next page

EXPANDED LOG
CORE NO: 25 continued
PROFILE: NONE
7.5 MIN QUAD: ERWINVILLE, LA



– (158 – 178 cm) organic – rich silt

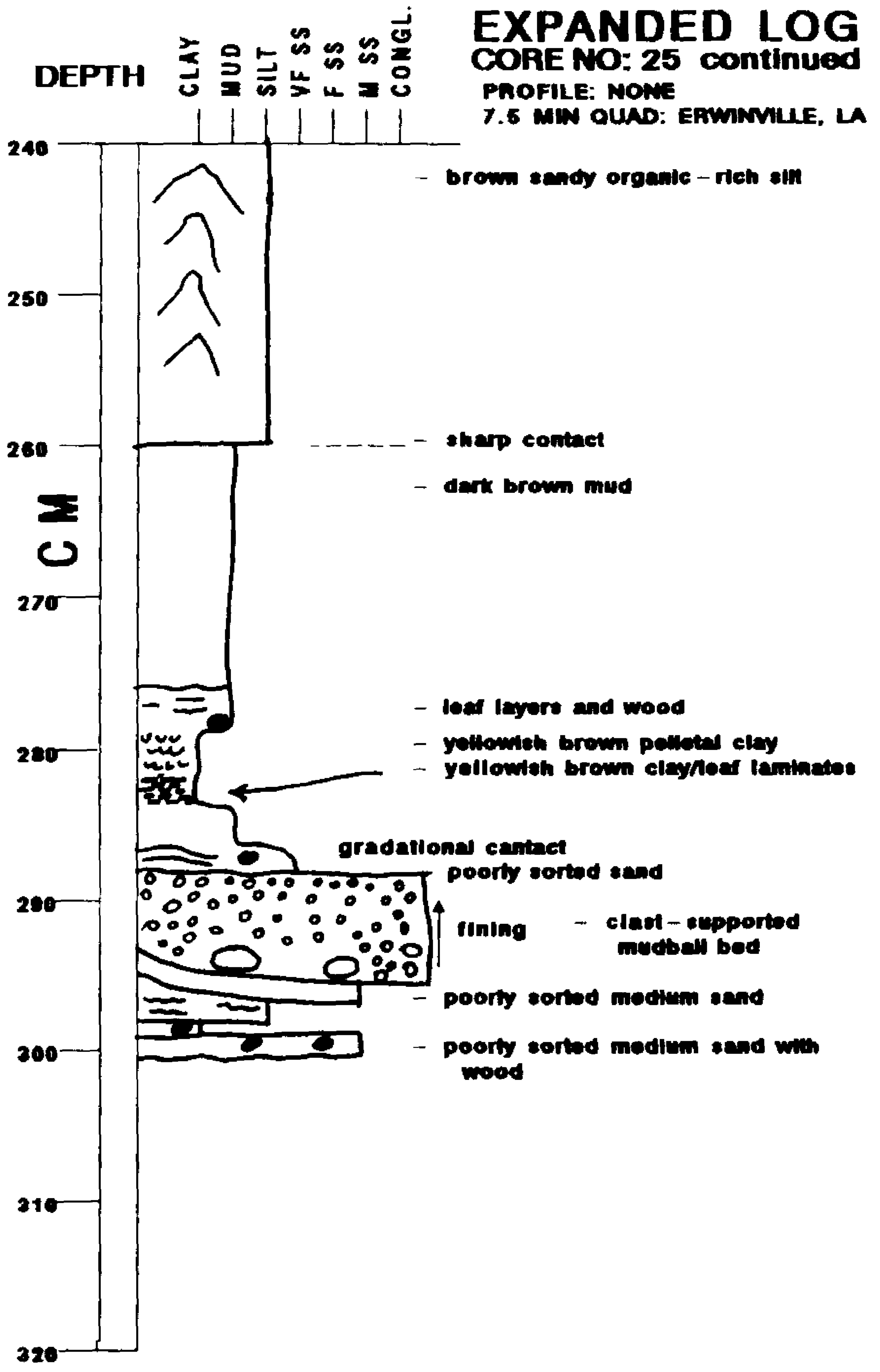
– (178 – 190) clean silt

patches of organic material
erratic laminations
some mud – rich zones

– silt, sandy
swirling laminations with organic – rich silt laminations
locally silt laminations are quite clean

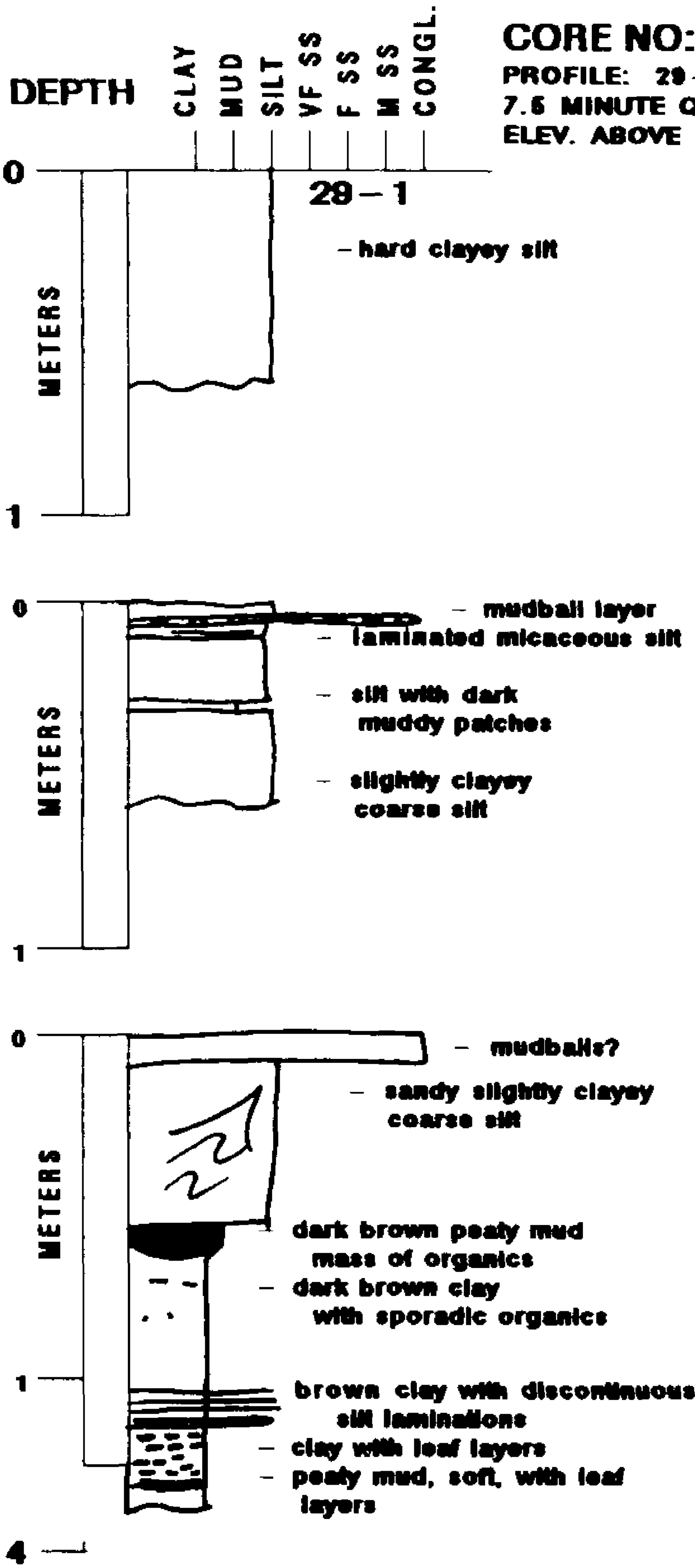
continued

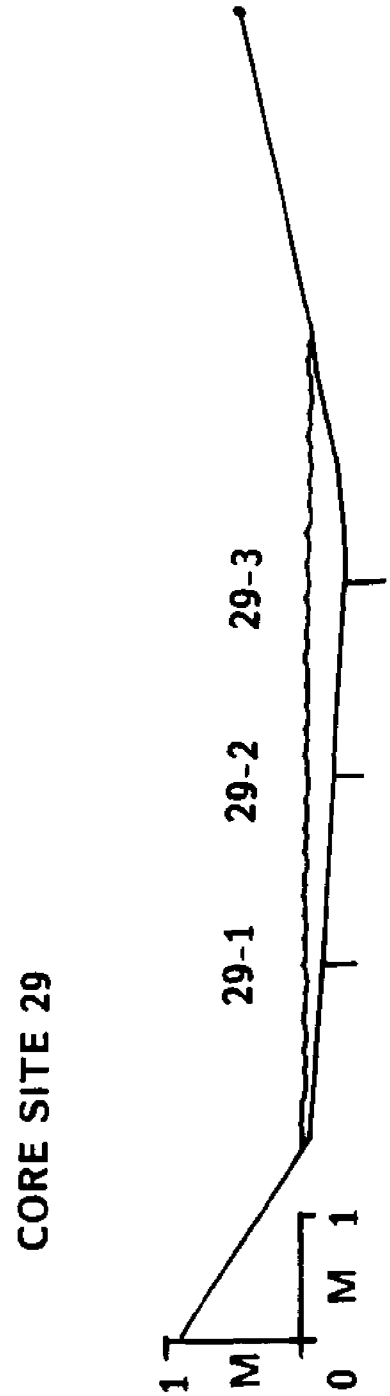
EXPANDED LOG
CORE NO: 25 continued
PROFILE: NONE
7.5 MIN QUAD: ERWINVILLE, LA



CORE NO: 29

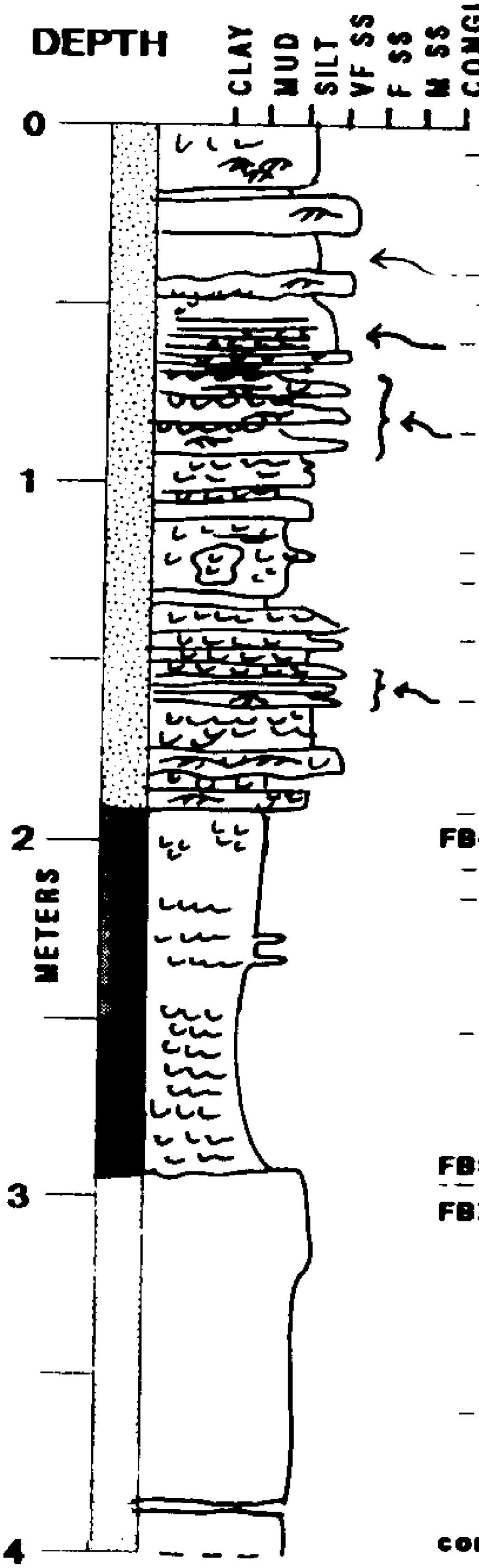
PROFILE: 29 – 1, 29 – 2, 29 – 3
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 23 ft





CORE NO: 37

PROFILE: E
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEVATION ABOVE M.S.L.: 32 FT
TEXT FIGURES: 30



- coarse silt
- small – scale trough cross – stratifica – tion
- slightly clayey coarse silt
- slightly clayey, sandy micaceous silt
- laminated very fine sand, burrows horizontal along laminae
- rhythmic layers, laminated to cross – laminated coarser layers finer layers partially burrowed
- burrow backfill (pellets) in sandy silt
- traces of laminations and cross – laminations
- pelletal lithologies: completely dis – rupted primary stratification
- graded layers: low angle ripple laminations with mud drapes

FB4:
- brownish mud with patches of silt
- pelletal silt zones

- dark brown pelletal clay loose silty zones

sand content decreases

FB8: dark brown pelletal mud

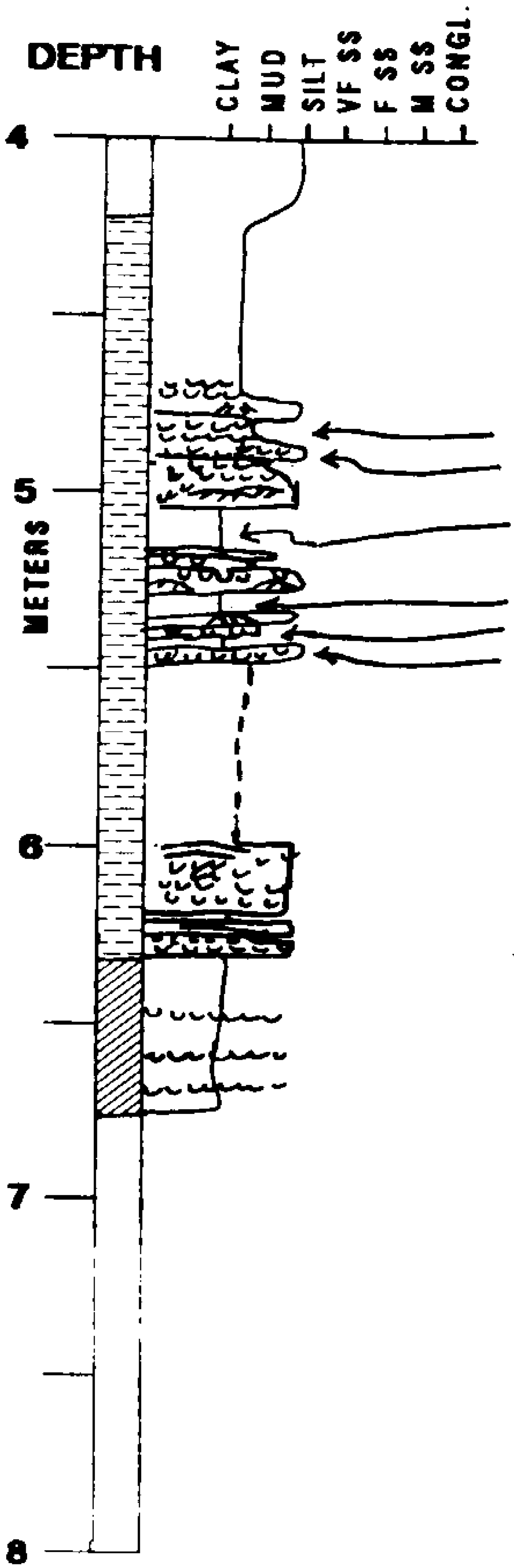
FB7: muddy sand, hard, poorly sorted nearly structureless

- silt, slightly clayey, coarse, dirty looking, hard

continued on next page

CORE NO: 37 continued

PROFILE: E
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 32 FT
TEXT FIGURES: 30



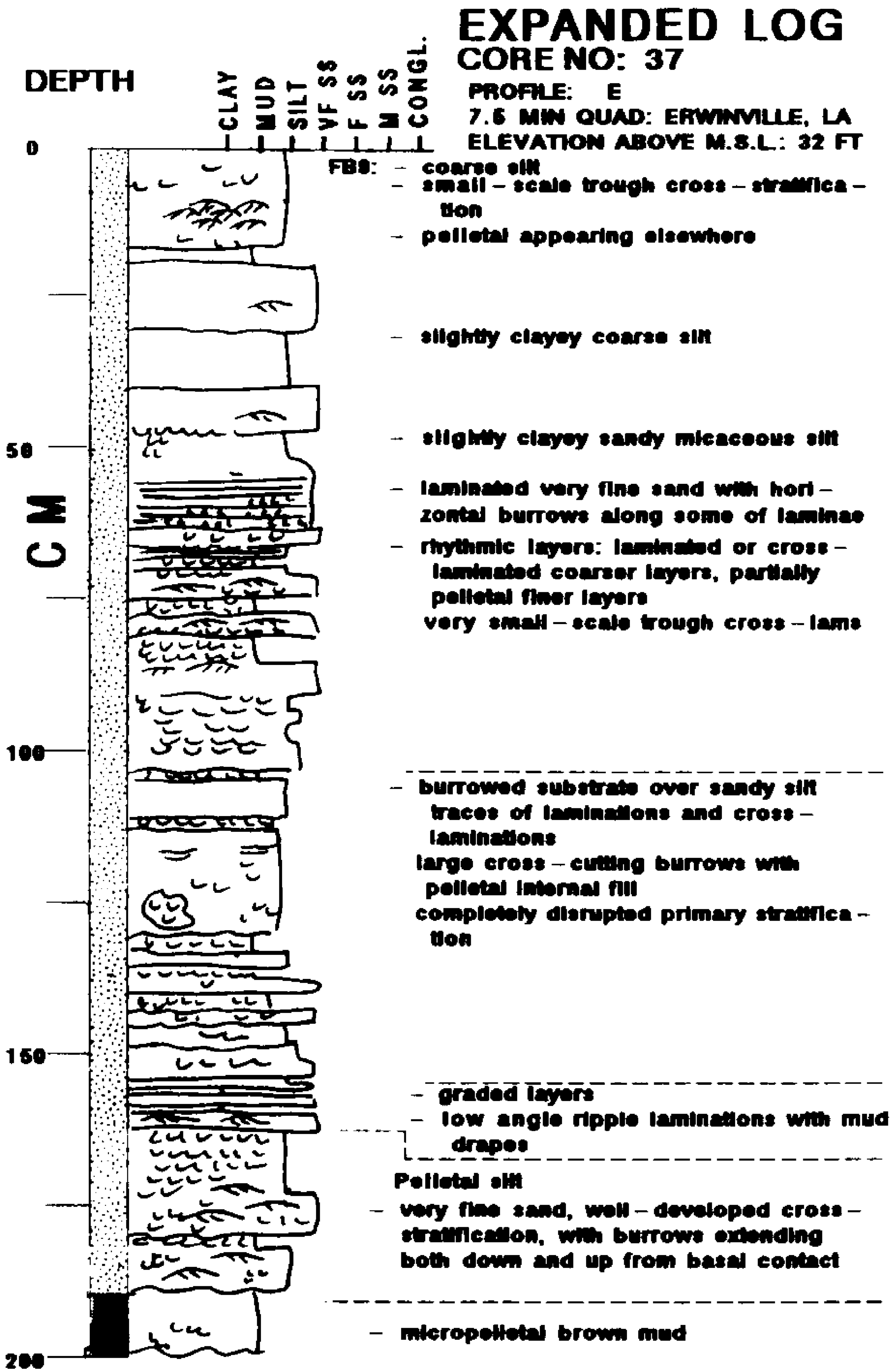
FB7: hard, slightly clayey silt

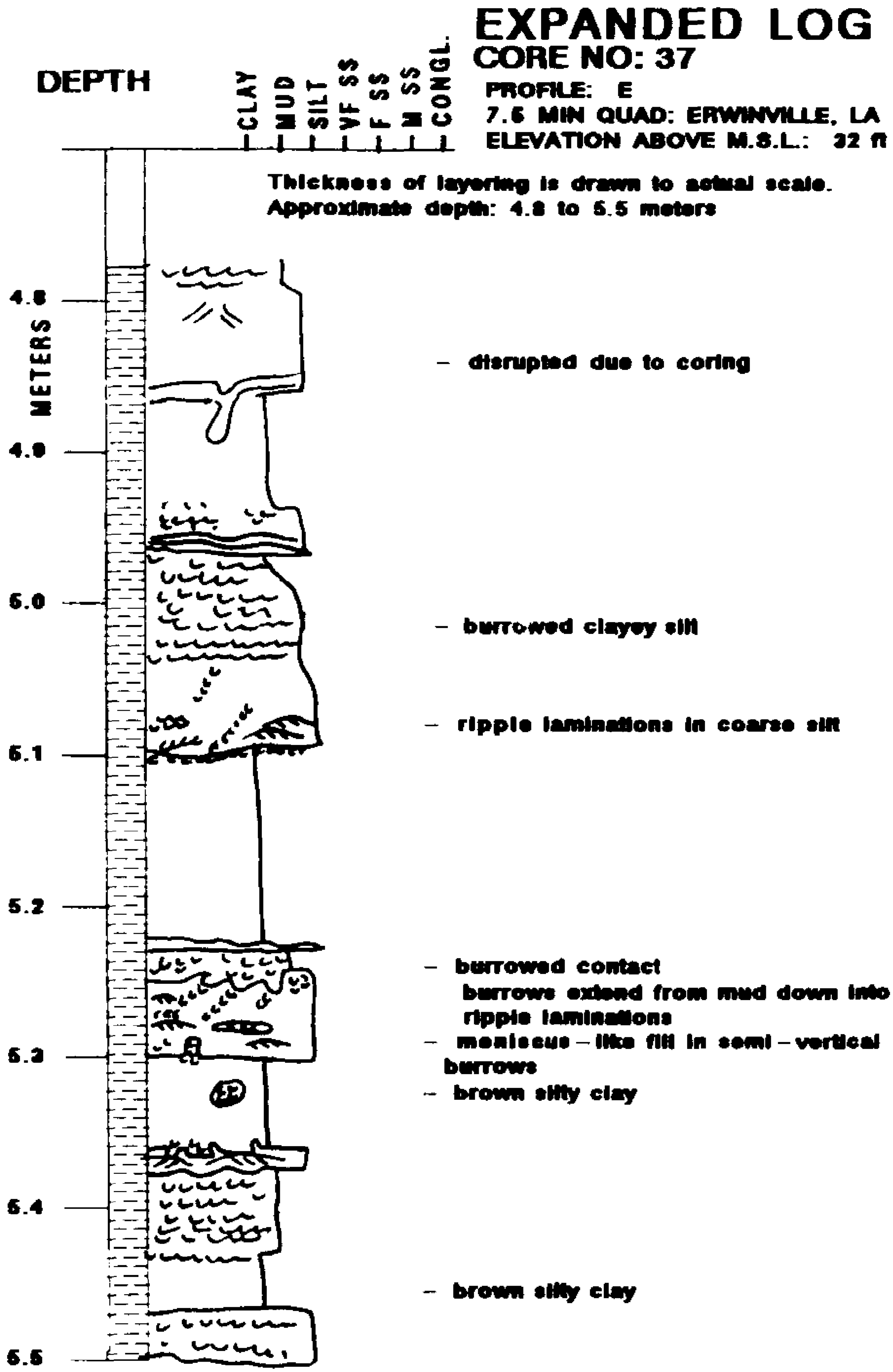
FB6: brown silty clay

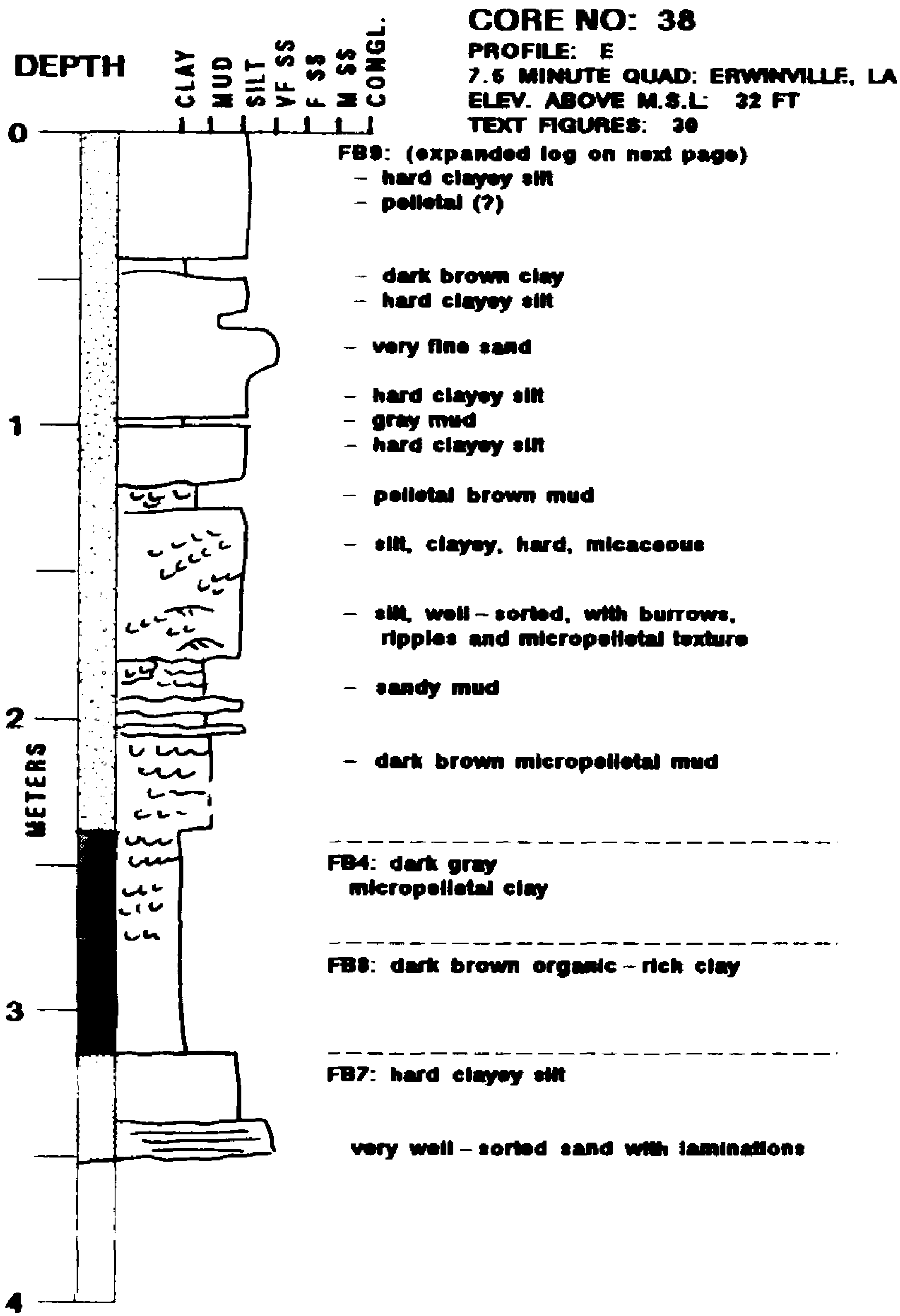
- clayey silt with disrupted laminae
- brown silty clay
- micropelletal silt
- brown silty clay
- brown silty clay
- pelletal mud
- pelletal clayey silt
- slump probably rhythmically layered
- extensively burrowed pelletal silt trace of laminations and cross-laminations

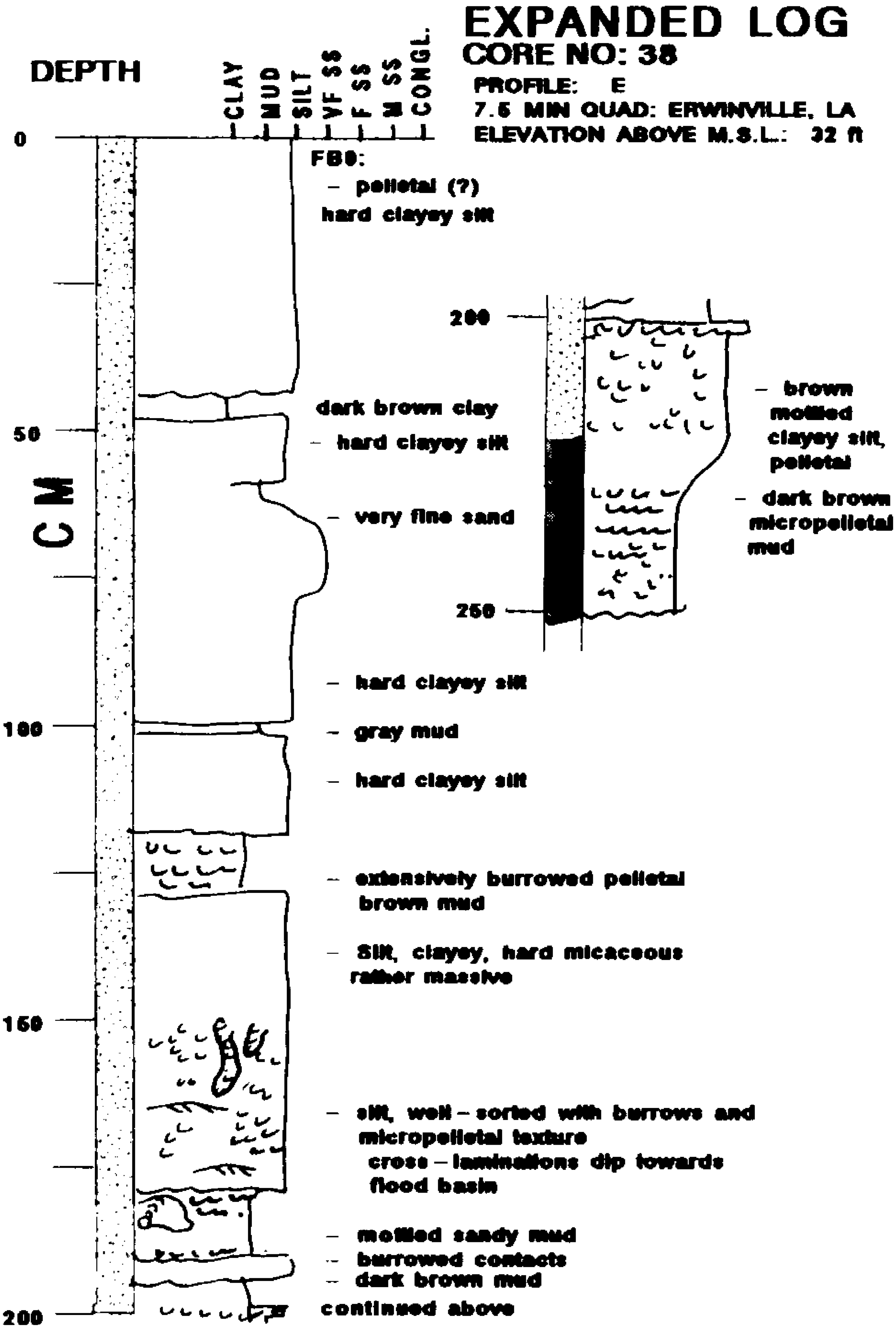
---

FB5:
- burrowed silty clay with disrupted pelletal silt layers


EXPANDED LOG
CORE NO: 37
PROFILE: E
7.5 MIN QUAD: ERWINVILLE, LA
ELEVATION ABOVE M.S.L.: 32 FT
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
50
100
150
200
C M
FBS: – coarse silt
– small – scale trough cross – stratifica – tion
– pelletal appearing elsewhere
– slightly clayey coarse silt
– slightly clayey sandy micaceous silt
– laminated very fine sand with hori – zontal burrows along some of laminae
– rhythmic layers: laminated or cross – laminated coarser layers, partially pelletal finer layers
very small – scale trough cross – lams
– burrowed substrate over sandy silt
traces of laminations and cross – laminations
large cross – cutting burrows with pelletal internal fill
completely disrupted primary stratifica – tion
– graded layers
– low angle ripple laminations with mud drapes
Pelletal silt
– very fine sand, well – developed cross – stratification, with burrows extending both down and up from basal contact
– micropelletal brown mud

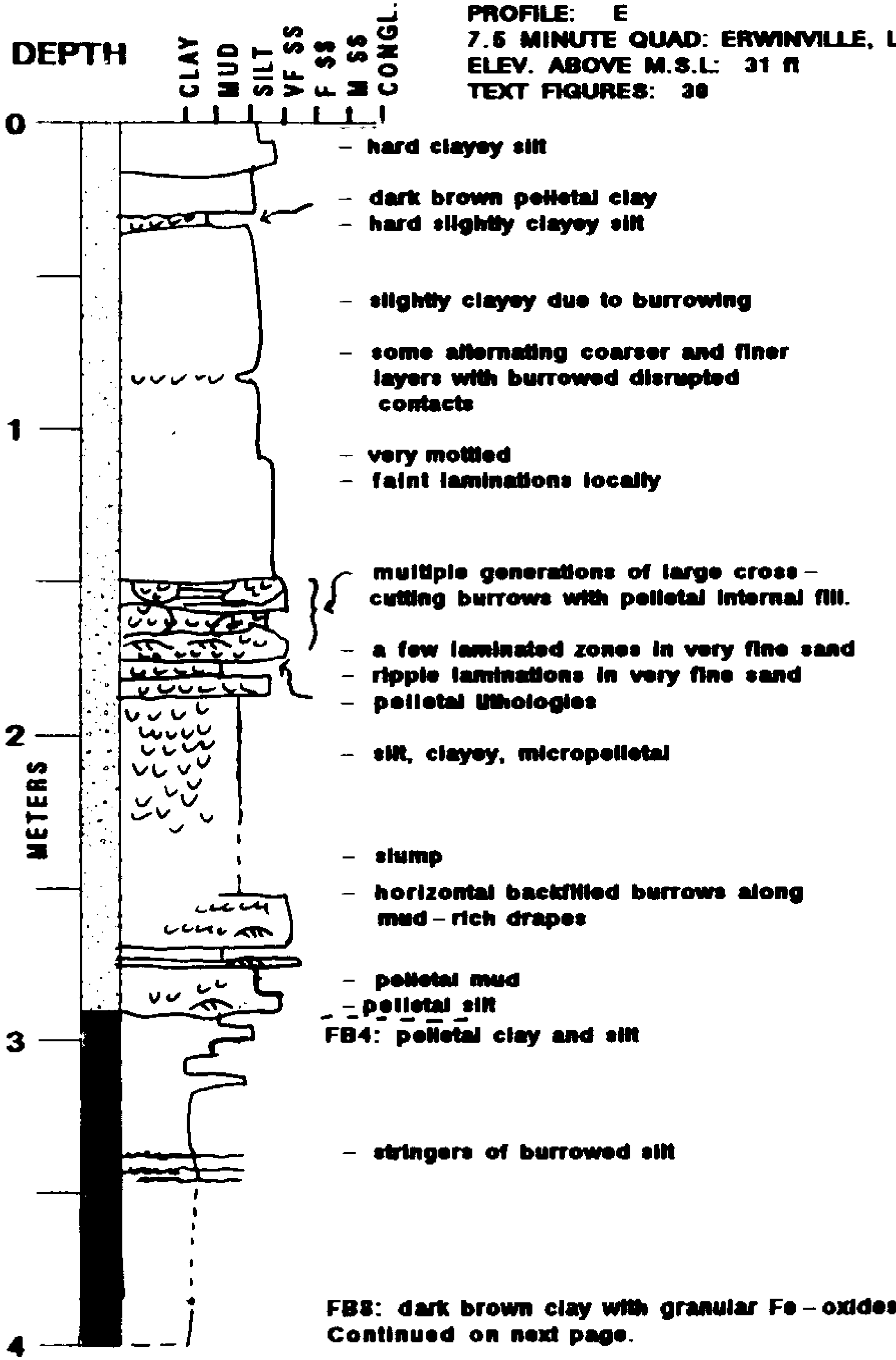

EXPANDED LOG
CORE NO: 37
PROFILE: E
7.5 MIN QUAD: ERWINVILLE, LA
ELEVATION ABOVE M.S.L.: 32 ft
DEPTH
METERS
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
Thickness of layering is drawn to actual scale.
Approximate depth: 4.8 to 5.5 meters
4.8
4.9
5.0
5.1
5.2
5.3
5.4
5.5
– disrupted due to coring
– burrowed clayey silt
– ripple laminations in coarse silt
– burrowed contact
burrows extend from mud down into ripple laminations
– meniscus – like fill in semi – vertical burrows
– brown silty clay
– brown silty clay


CORE NO: 38
PROFILE: E
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 32 FT
TEXT FIGURES: 30
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
1
2
3
4
METERS
FB9: (expanded log on next page)
– hard clayey silt
– pelletal (?)
– dark brown clay
– hard clayey silt
– very fine sand
– hard clayey silt
– gray mud
– hard clayey silt
– pelletal brown mud
– silt, clayey, hard, micaceous
– silt, well – sorted, with burrows, ripples and micropelletal texture
– sandy mud
– dark brown micropelletal mud
FB4: dark gray micropelletal clay
FB8: dark brown organic – rich clay
FB7: hard clayey silt
very well – sorted sand with laminations


EXPANDED LOG
CORE NO: 38
PROFILE: E
7.5 MIN QUAD: ERWINVILLE, LA
ELEVATION ABOVE M.S.L.: 32 ft
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
C M
0
50
100
150
200
250
FB0:
– pelletal (?)
hard clayey silt
dark brown clay
– hard clayey silt
– very fine sand
– hard clayey silt
– gray mud
– hard clayey silt
– extensively burrowed pelletal brown mud
– Silt, clayey, hard micaceous rather massive
– silt, well – sorted with burrows and micropelletal texture
cross – laminations dip towards flood basin
– mottled sandy mud
– burrowed contacts
– dark brown mud
continued above
– brown mottled clayey silt, pelletal
– dark brown micropelletal mud

CORE NO: 39

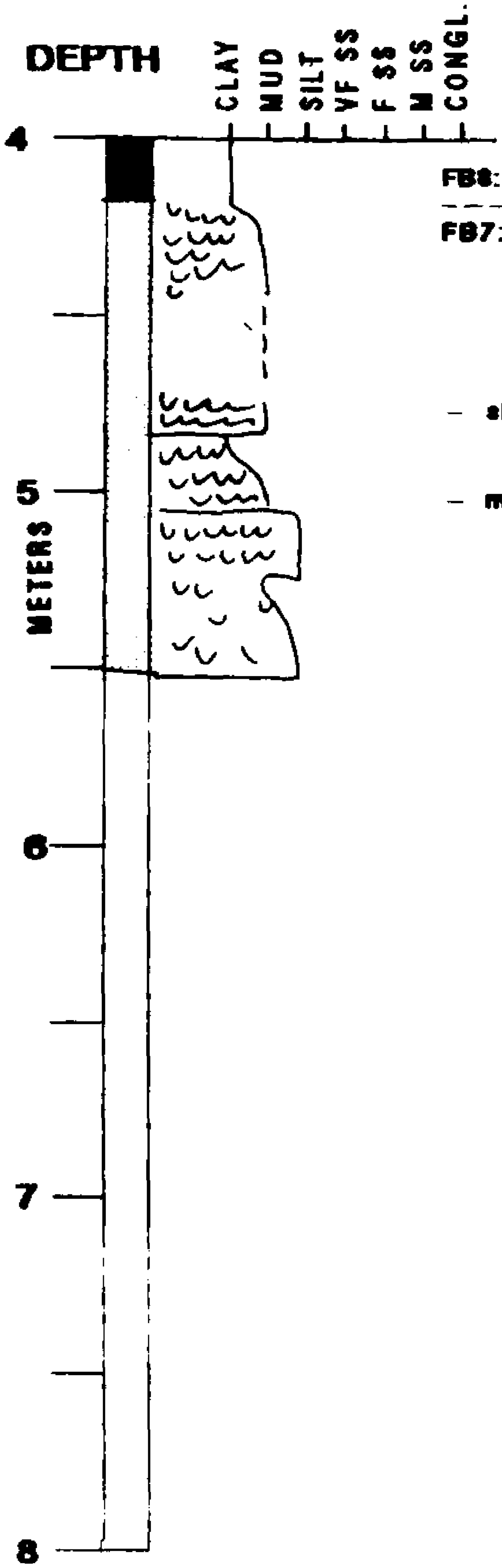
PROFILE: E
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 31 ft
TEXT FIGURES: 39



Continued on next page.

CORE NO: 39 continued

PROFILE: E
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 31 ft
TEXT FIGURES: 30



FB8: dark brown clay

FB7: tan silt – clay, micropelletal massive appearing

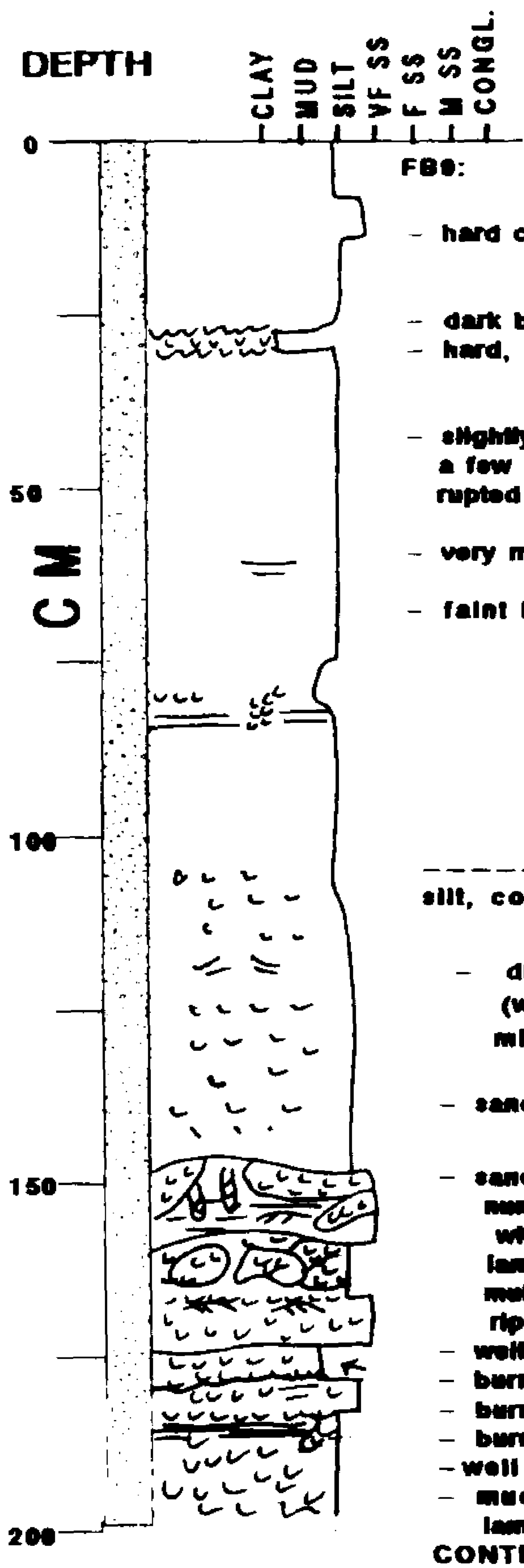
– slump

– micropelletal mud, silt, clay

EXPANDED LOG

CORE NO: 39

PROFILE: E
7.5 MIN QUAD: ERWINVILLE, LA
ELEVATION ABOVE M.S.L.: 31 ft.



FB9:

- hard clayey silt
- dark brown clay with pelletal silt
- hard, slightly clayey silt
- slightly clayey due to burrowing
  a few alternating coarser and finer dis-rupted beds
- very mottled appearing
- faint laminations

---

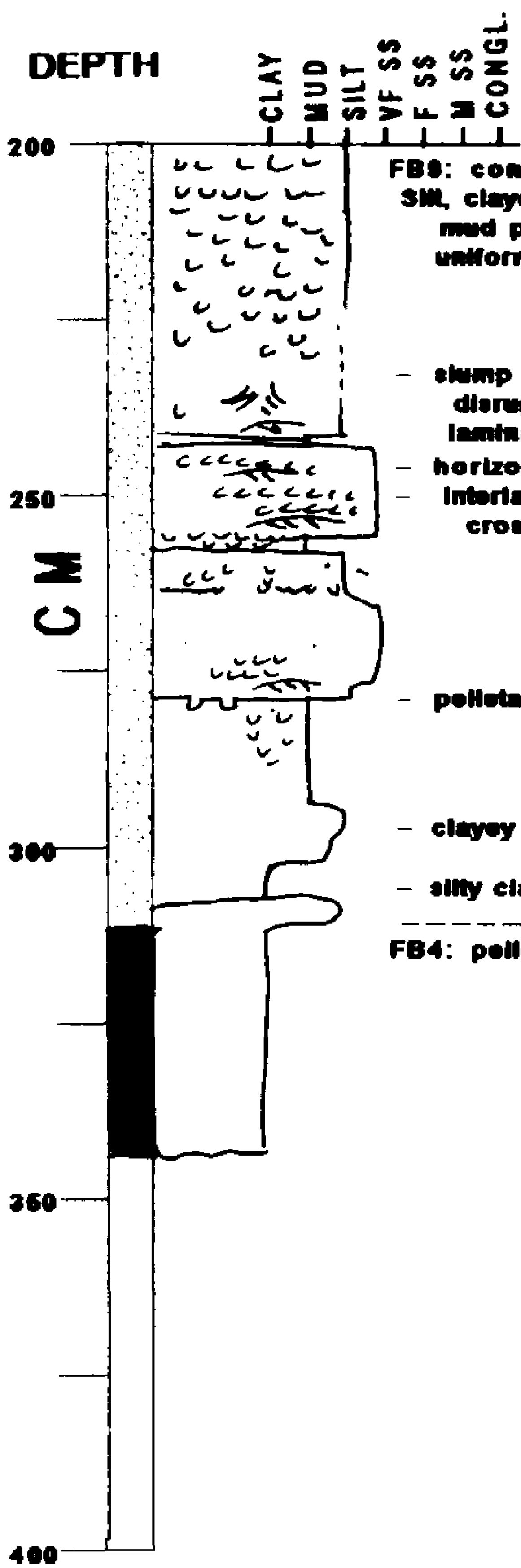
silt, coarse, patchily mottled to pelletal

- disrupted laminations
  (water escape)
  micaceous
- sand, fine to very fine silty
- sand, very fine
  numerous large cross-cutting burrows
  with pelletal internal fill.
  laminations
  multiple generations of burrows
  ripples and laminations
- well-sorted very fine sand
- burrowed very fine pelletal sand
- burrows, pelletal sandy mud
- burrowed contact
- well-sorted silt
- mud-filled burrows cross-cutting
  laminated silt

CONTINUED ON NEXT PAGE

EXPANDED LOG
CORE NO: 39 CONTINUED

PROFILE: E
7.5 MIN QUAD: ERWINVILLE, LA
ELEVATION ABOVE M.S.L.: 32 FT



FB9: continued
Silt, clayey
mud pellets surrounded by silt matrix
uniformly pelletal

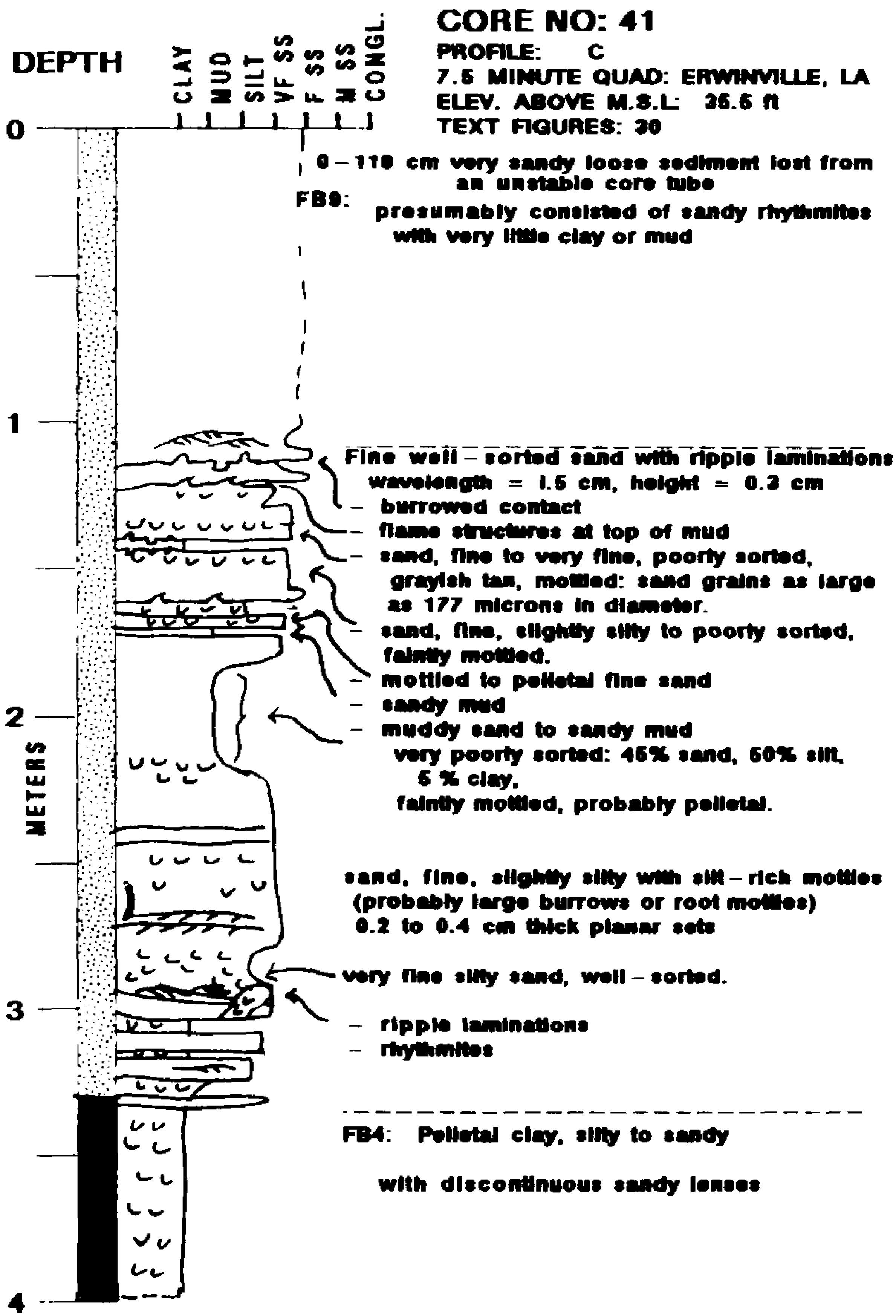
– slump
disrupted very fine sand and silt, laminated in lower part
– horizontal backfilled burrows
– interlayered pelletal mud drapes and cross – laminated very fine sand

– pelletal mud

– clayey silt

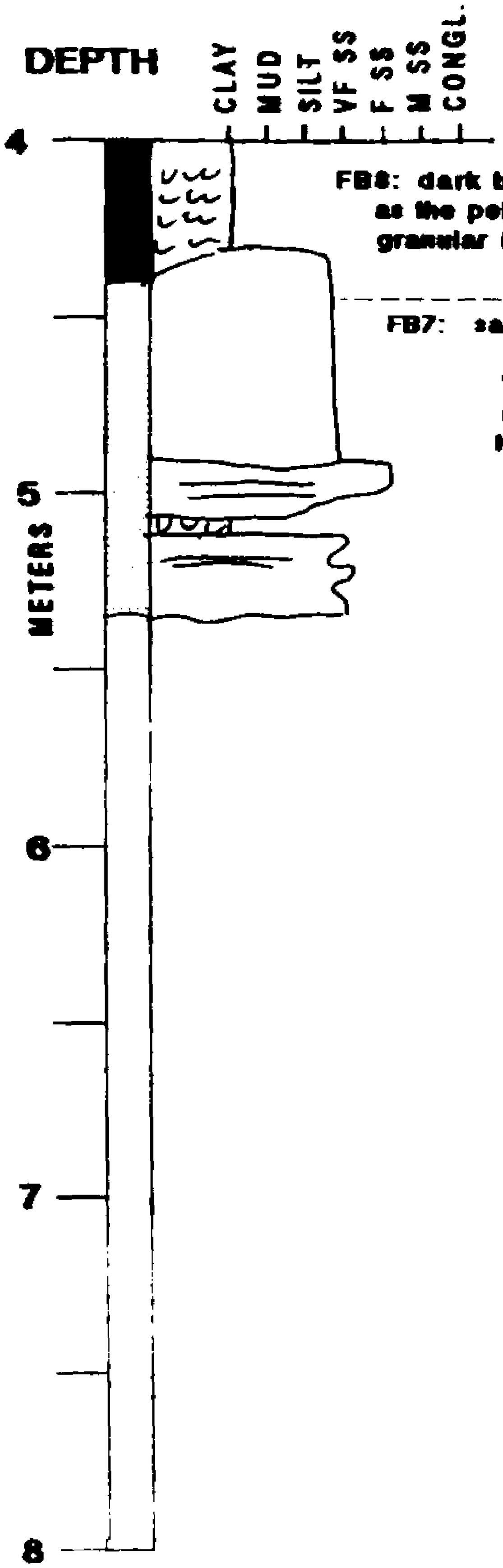
– silty clay

FB4: pelletal mud and clay


CORE NO: 41
PROFILE: C
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 35.5 ft
TEXT FIGURES: 30
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
METERS
0
1
2
3
4
0 – 110 cm very sandy loose sediment lost from an unstable core tube
FB9:
presumably consisted of sandy rhythmites with very little clay or mud
Fine well – sorted sand with ripple laminations wavelength = 1.5 cm, height = 0.2 cm
– burrowed contact
– flame structures at top of mud
– sand, fine to very fine, poorly sorted, grayish tan, mottled: sand grains as large as 177 microns in diameter.
– sand, fine, slightly silty to poorly sorted, faintly mottled.
– mottled to pelletal fine sand
– sandy mud
– muddy sand to sandy mud very poorly sorted: 45% sand, 50% silt, 5 % clay, faintly mottled, probably pelletal.
sand, fine, slightly silty with silt – rich mottles (probably large burrows or root mottles) 0.2 to 0.4 cm thick planar sets
very fine silty sand, well – sorted.
– ripple laminations
– rhythmites
FB4: Pelletal clay, silty to sandy
with discontinuous sandy lenses

CORE NO: 41 continued

PROFILE: C
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 31.5 ft
TEXT FIGURES: 38

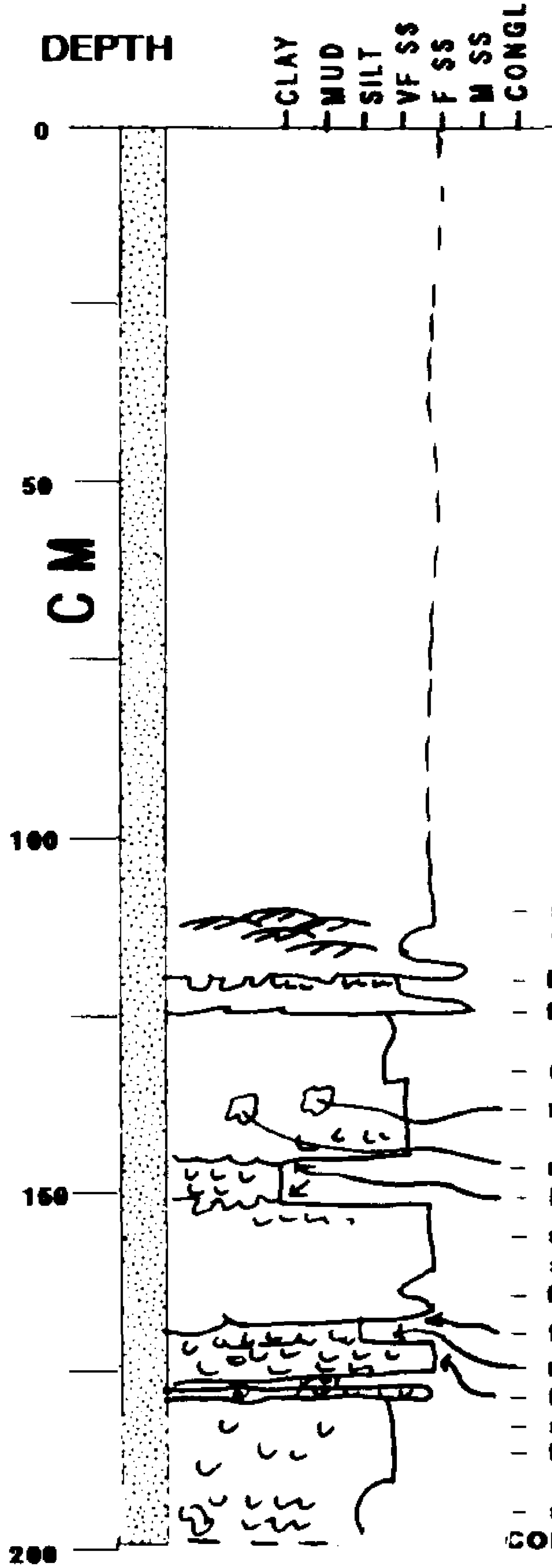


FB8: dark brown micropelletal clay with sand as the pelletal fabric matrix, granular Fe – oxides

FB7: sand, clayey, silty micaceous, 'massive' mud = 20% hard

EXPANDED LOG
CORE NO: 41

PROFILE: C
7.5 MIN QUAD: ERWINVILLE, LA
ELEVATION ABOVE M.S.L.: 31.5 ft



CONTINUED

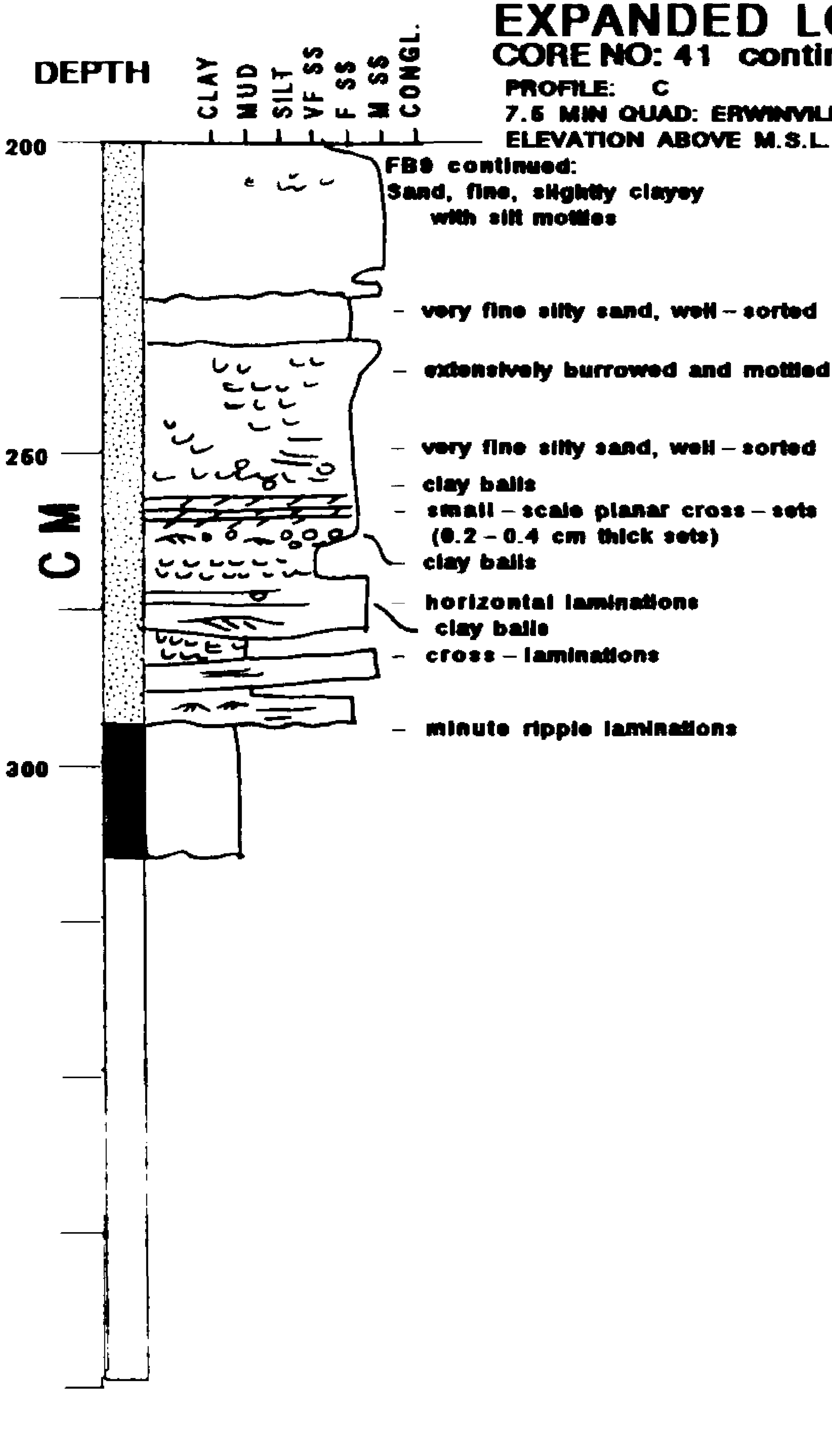
EXPANDED LOG

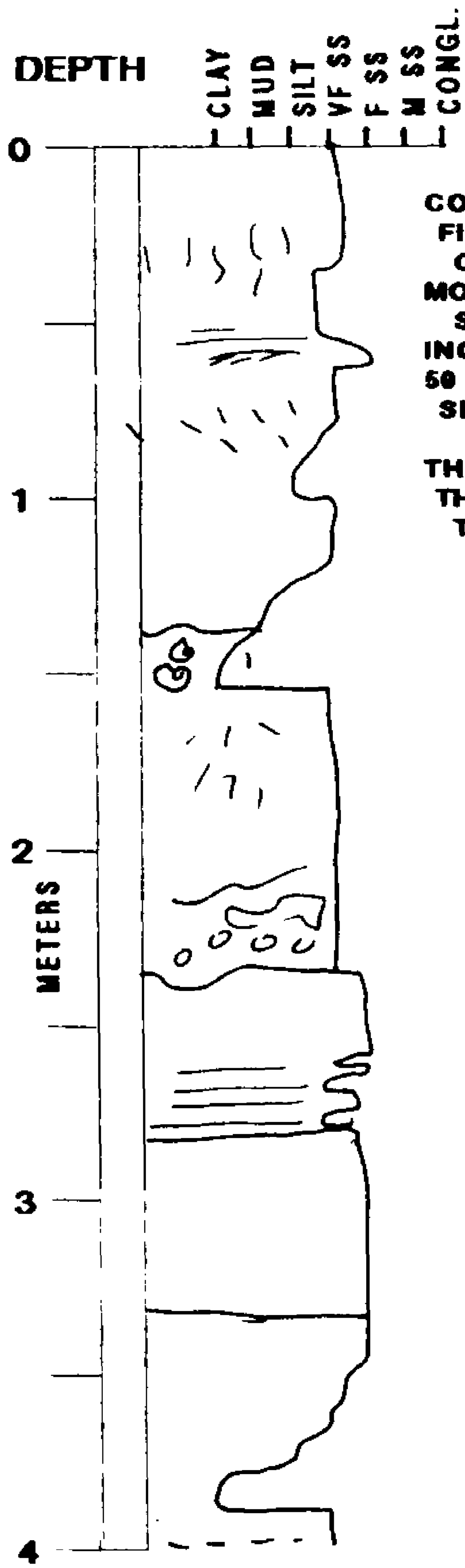
CORE NO: 41 continued

PROFILE: C

7.5 MIN QUAD: ERWINVILLE, LA

ELEVATION ABOVE M.S.L.: 31.5 ft





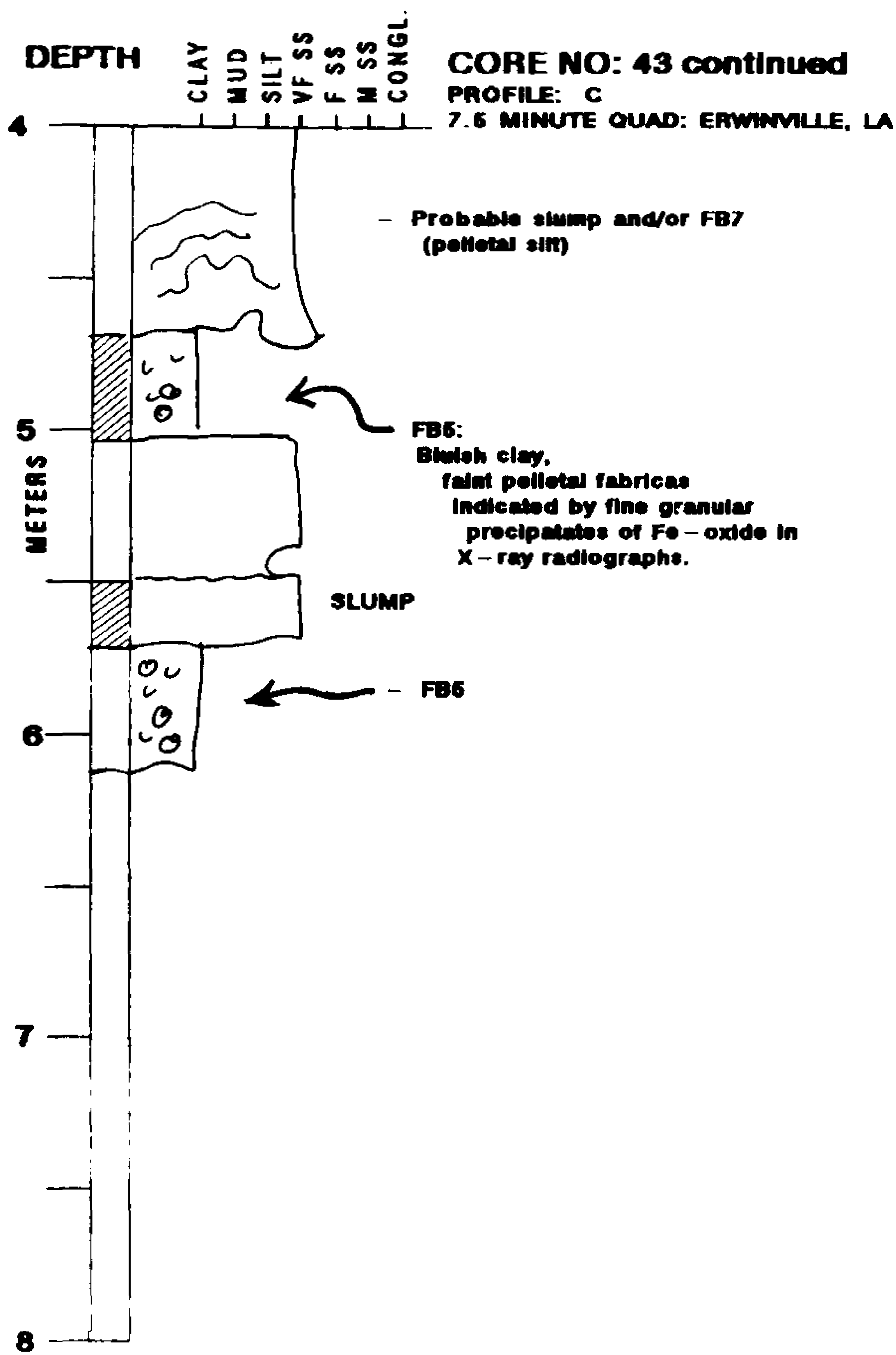
CORE NO: 43

PROFILE: C
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L:
TEXT FIGURES: 30

CORE THROUGH ROADBED COMPOSED OF FILL DUMPED INTO OPEN CREVASSE CHANNEL.
MOST OF THE MATERIAL LOGGED IS SLUMP OR ROADFILL.
INCREMENTAL CORING CAUSES UPPER 50 % OF CORE TUBE TO BE FILLED WITH SLUMP IN THIS PARTICULAR CORE.

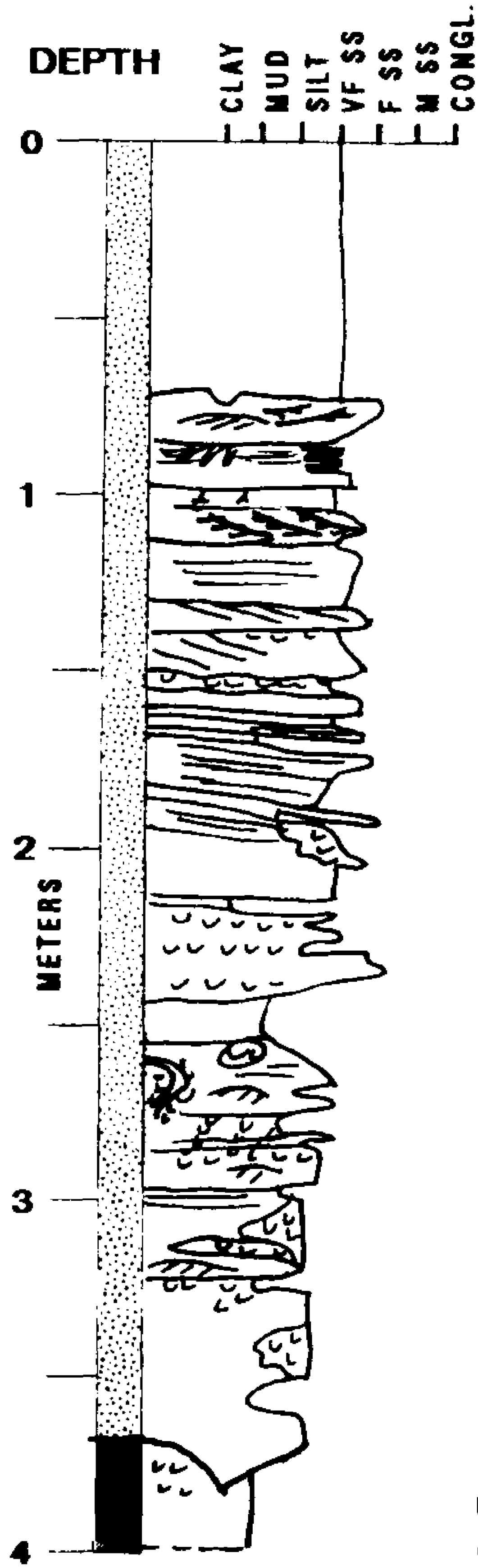
THE IMPORTANCE OF THIS CORE IS SIMPLY THAT:
THE DEEPEST IN PLACE SEDIMENT CONSISTS OF FB6, BLUISH CLAY WITH NODULES (SEE NEXT PAGE).

CONTINUED ON NEXT PAGE


DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
CORE NO: 43 continued
PROFILE: C
7.5 MINUTE QUAD: ERWINVILLE, LA
4
5
METERS
6
7
8
– Probable slump and/or FB7
(pelletal silt)
FB5:
Bluish clay,
faint pelletal fabricas
indicated by fine granular
precipatates of Fe – oxide in
X – ray radiographs.
SLUMP
– FB5

CORE NO: 44

PROFILE: C
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L:
TEXT FIGURES: 30, 39, 49



FB9: very fine silty sand
- alternating zones of clay – rich and clay free, structureless silty sand
- small – scale ripple drift
- small – scale ripple drift
- graded parallel laminations each normally graded layer is about 0.8 cm thick
- inclined parallel laminations
- clay drapes
- inclined parallel laminations
- extensively burrowed by large cross – cutting burrows with pelletal internal fabric
- traces of parallel and cross – laminations

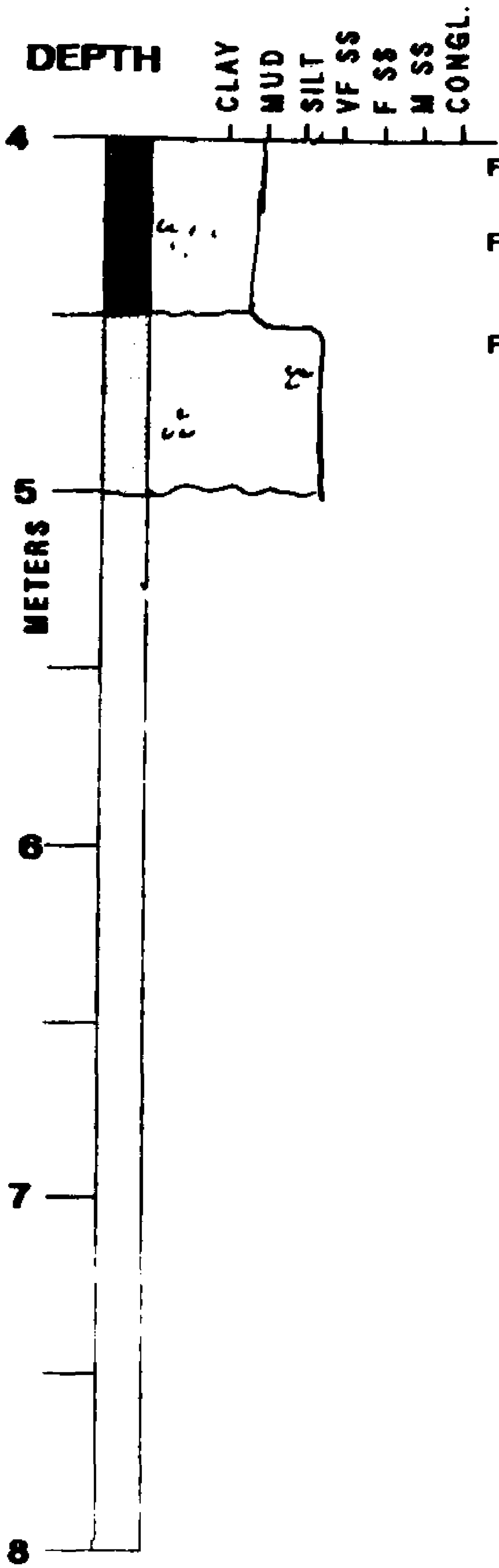
FB4: – dark gray clay

continued on next page

CORE NO: 44 continued

PROFILE: C

7.5 MINUTE QUAD: ERWINVILLE, LA

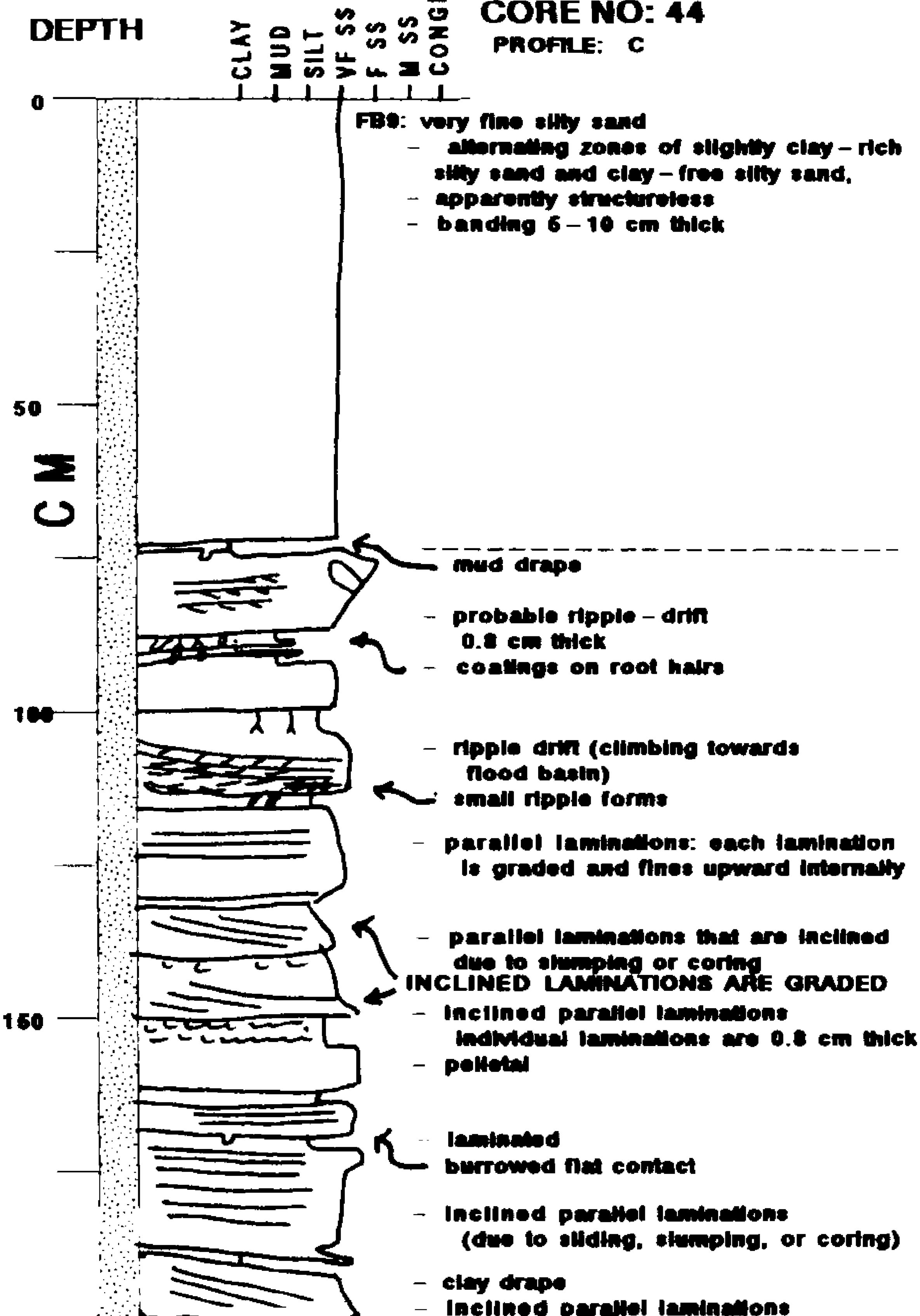


FB4: sandy mud

FB8: dark brown sandy mud

FB7: clayey sand and silt, hard
poorly sorted
pelletal fabric as indicated by
granular Fe – oxides in
X – ray radiographs
Pelletal silt

EXPANDED LOG
CORE NO: 44
PROFILE: C

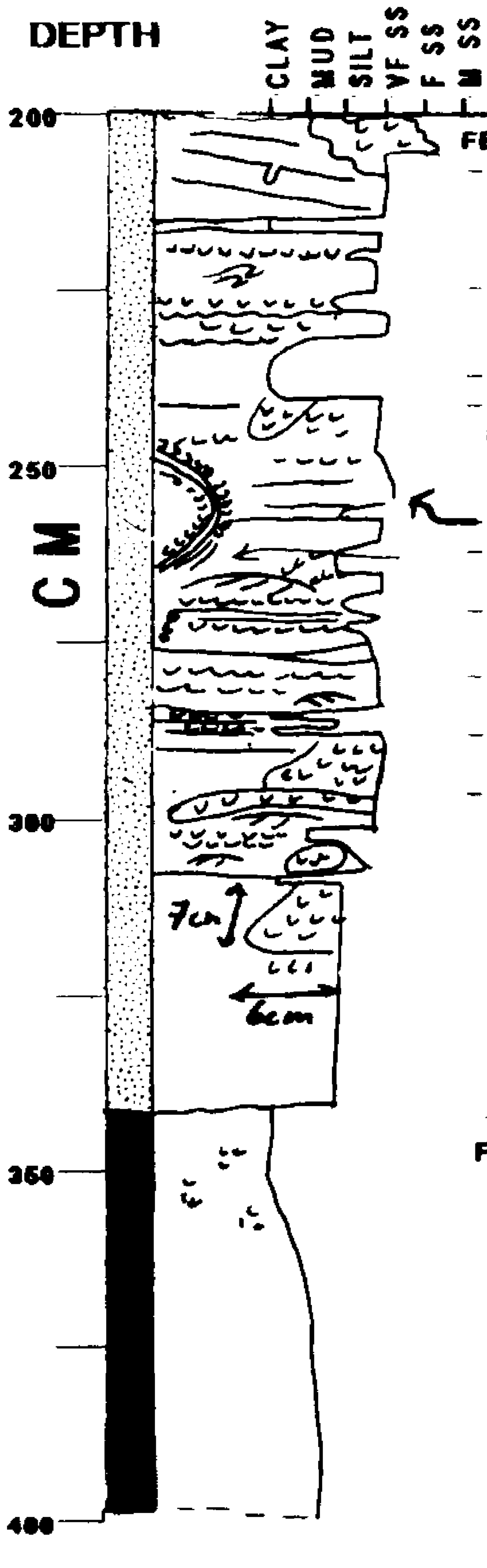


CONTINUED ON NEXT PAGE

EXPANDED LOG

CORE NO: 44

PROFILE: C
7.5 MIN QUAD: ERWINVILLE, LA



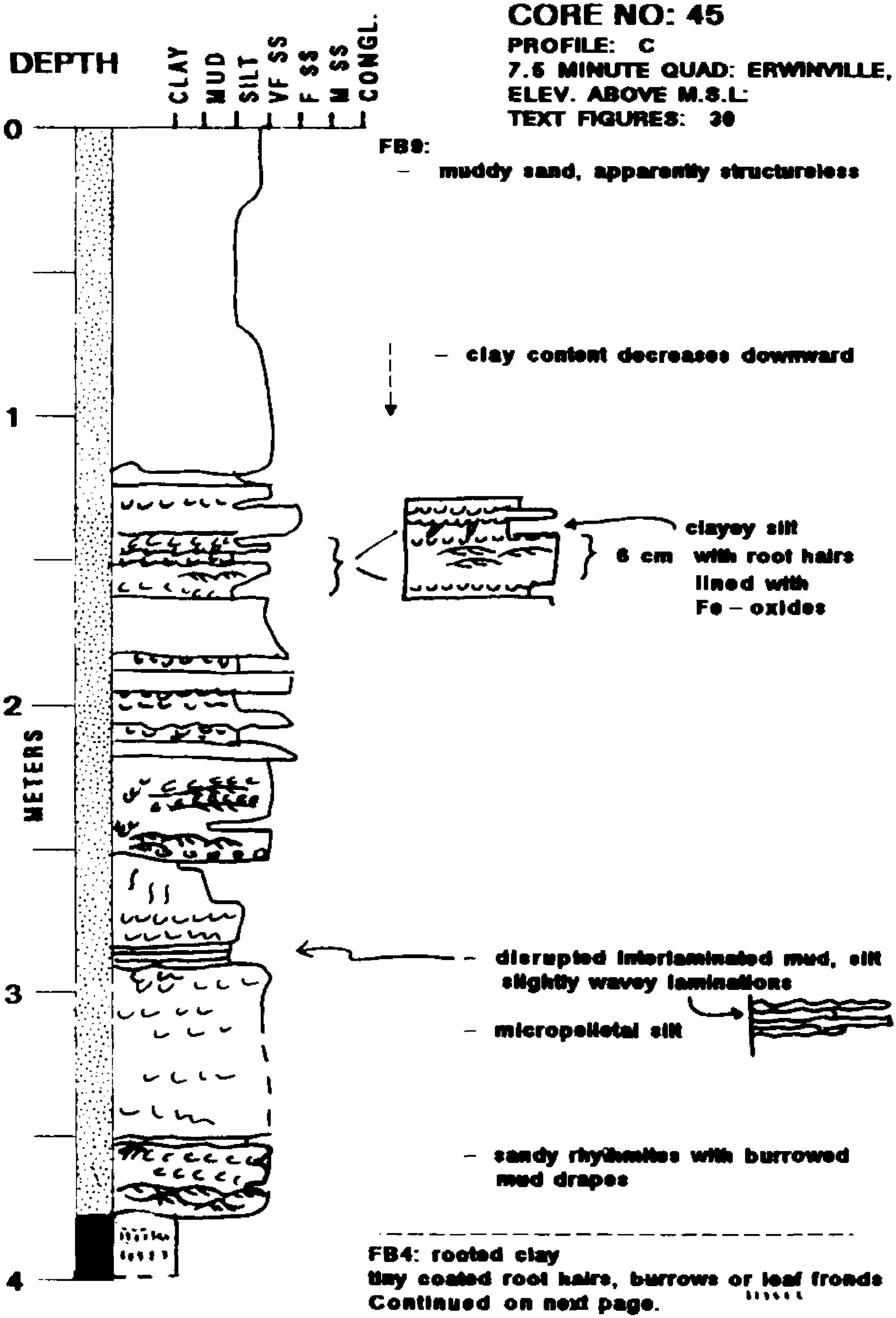
FB9 continued:
- inclined parallel laminations, U – shaped burrows
- pelletal lithologies
- dark gray clay
- large burrows with pelletal internal fabric are superimposed on rhythmically layered sediment
- faint laminations
- clay lining along large burrow or root mottle
- burrow lined with pellets like *Callianassa nodosa*
- straight burrows extend downward from laminations (U – shaped)
- silt/clay laminations, burrowed
- large cross – cutting burrows with micropelletal internal fabric

---

FB4: dark gray clay

CORE NO: 45

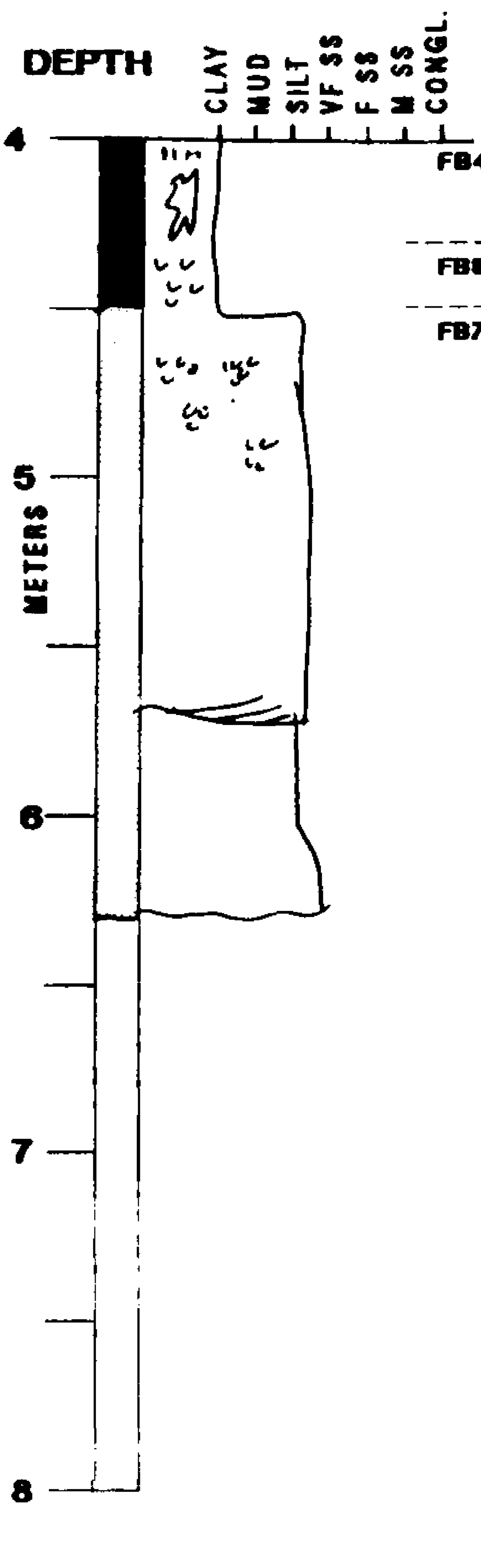
PROFILE: C
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L:
TEXT FIGURES: 30



CORE NO: 45 continued

PROFILE: C

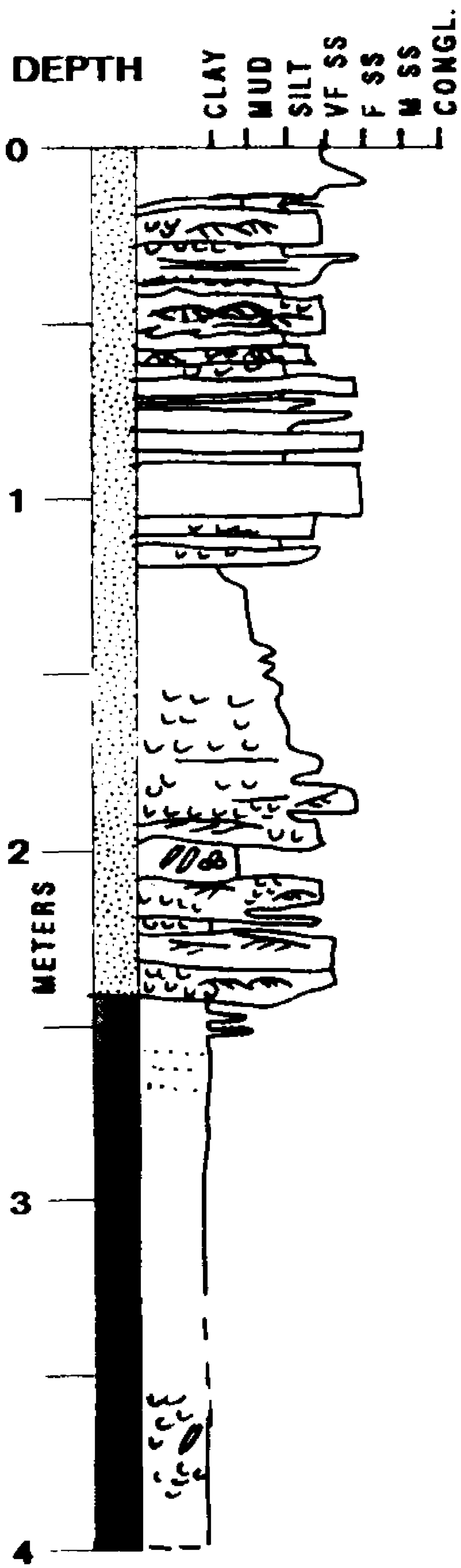
7.5 MINUTE QUAD: ERWINVILLE, LA



FB4: rooted clay

FB6: dark brown pelletal clay

FB7: very fine silty sand with granular Fe – oxides associated with a pelletal fabric



CORE NO: 46
PROFILE: C
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L:
TEXT FIGURES: 30

FB9:
Rhythmically layered sand, muddy, silt, mud and clay.
- **pink clay**
- **small – scale trough cross – sets**
- **flame structures at top of clayey silt**

Sandy rhythmites –
fine sand layers separated by clayey silt layers.
internal stratification obscured

- **dark gray silty clay**
- **micropelletal silt**

- **well – developed vertical coated root hairs**

- **small – scale ripple – drift**

FB4:
- **micropelletal brown clay with banding and horizontal druses probable algal mats(?) or micro – root hairs**

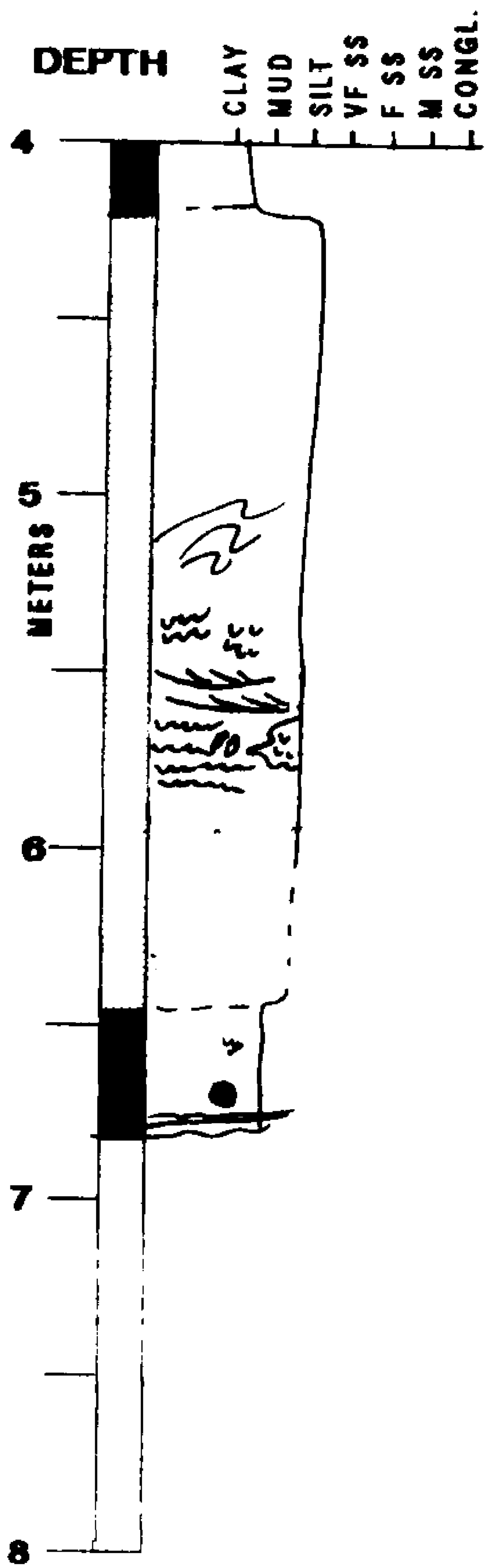
- **slump in core tubes**

- **dark gray with granular Fe – oxides in silty patches caused by pelletal fabric.**

Continued

CORE NO: 46 Continued

PROFILE: C
7.5 MINUTE QUAD: ERWINVILLE, LA



FB8: dark brown micropelletal clay

FB7:

- **disrupted laminations**
- **concretions not present**
- **burrowed clay/silt laminates (SEE NEXT PAGE FOR EXPANDED LOG)**
- **large cross-cutting burrow**
- **rootlets with carbonate coatings**
- **slump in core tube**
- **mottled contact**

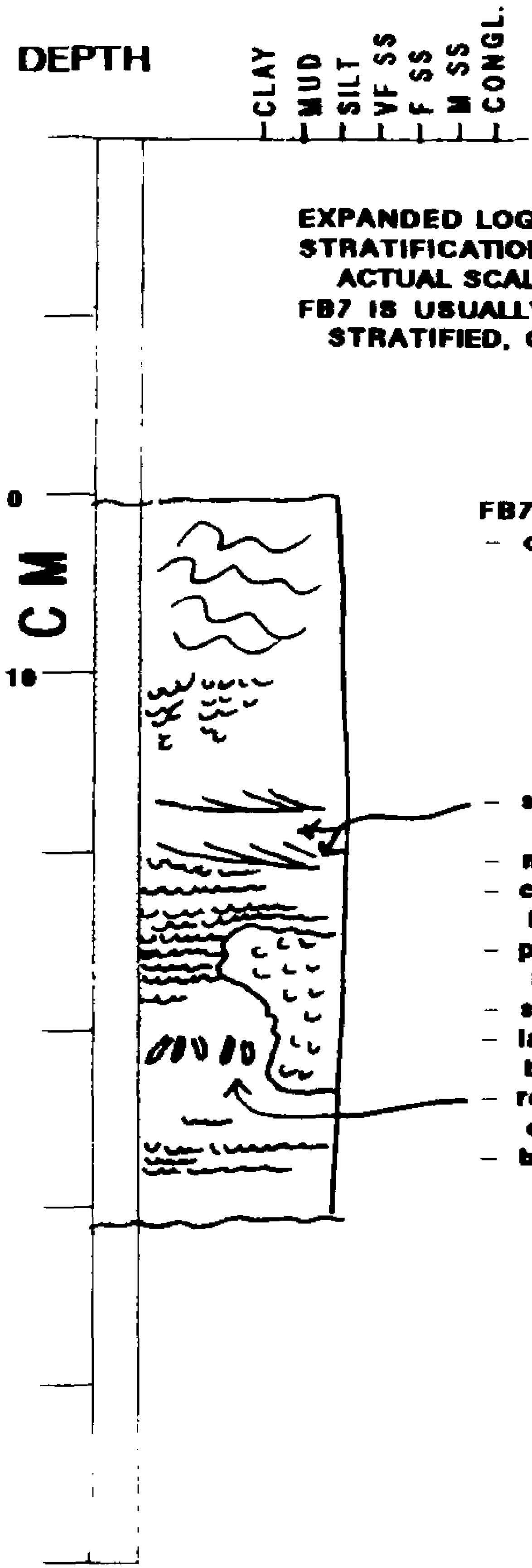
FB6: dark blue smooth, soft, very silty clay or clayey silt
- **wood**

EXPANDED LOG

CORE NO: 46

PROFILE: C

7.5 MIN QUAD: ERWINVILLE, LA

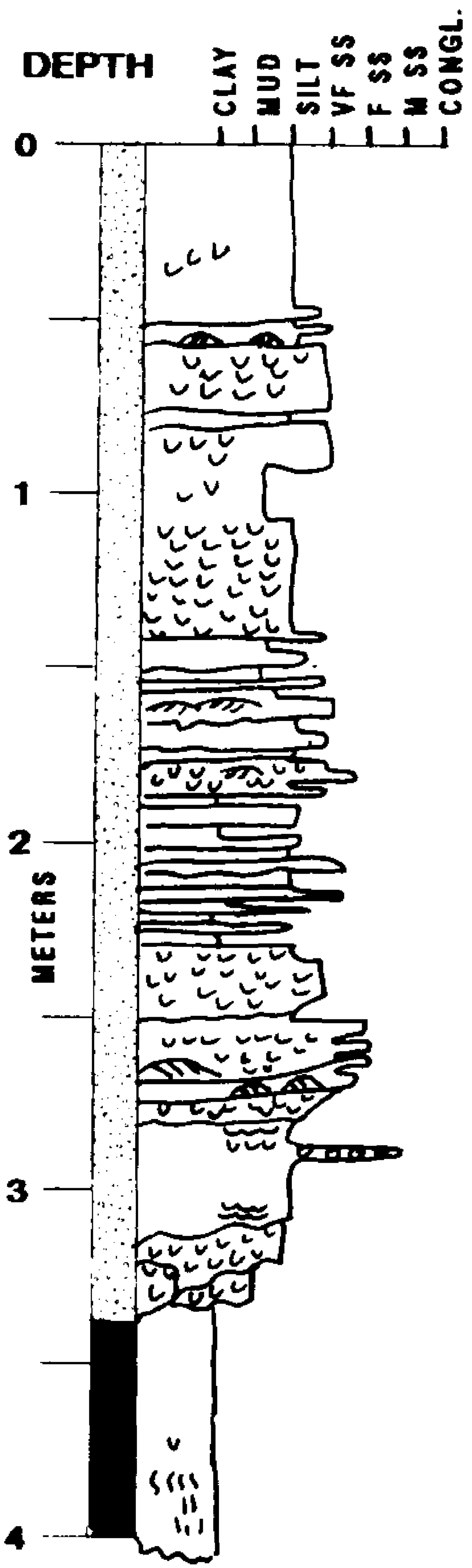


EXPANDED LOG FOR UNIT FB7.
STRATIFICATION IS REPRODUCED HERE AT ITS ACTUAL SCALE.
FB7 IS USUALLY STRUCTURELESS, POORLY STRATIFIED, OR POORLY PRESERVED IN THE CORE.

FB7:
- disrupted laminations
- scour surfaces overlain by tangential inclined laminations
- minutely interlaminated clay/silt
- clay layers have a beaded appearance because of horizontal burrowers
- pelletal fabric restricted to clay laminations that are only 1 mm thick
- silt laminations are not burrowed
- large cross-cutting burrow disrupts burrowed laminates
- row of vertical roothairs with carbonate coatings
- burrowed clay/silt laminates

CORE NO: 47

PROFILE: D
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 35 FT.
TEXT FIGURES: 36,37



FB9:

0 – 140 cm: extensively mottled silt and very fine sand.
- **slightly banded and massive appearing**
- **micropelletal silt**

- **sandy and silty rhythmites: coarser layers well – stratified ripple forms have thin clay drapes clay drapes are burrowed into pelletal fabric**

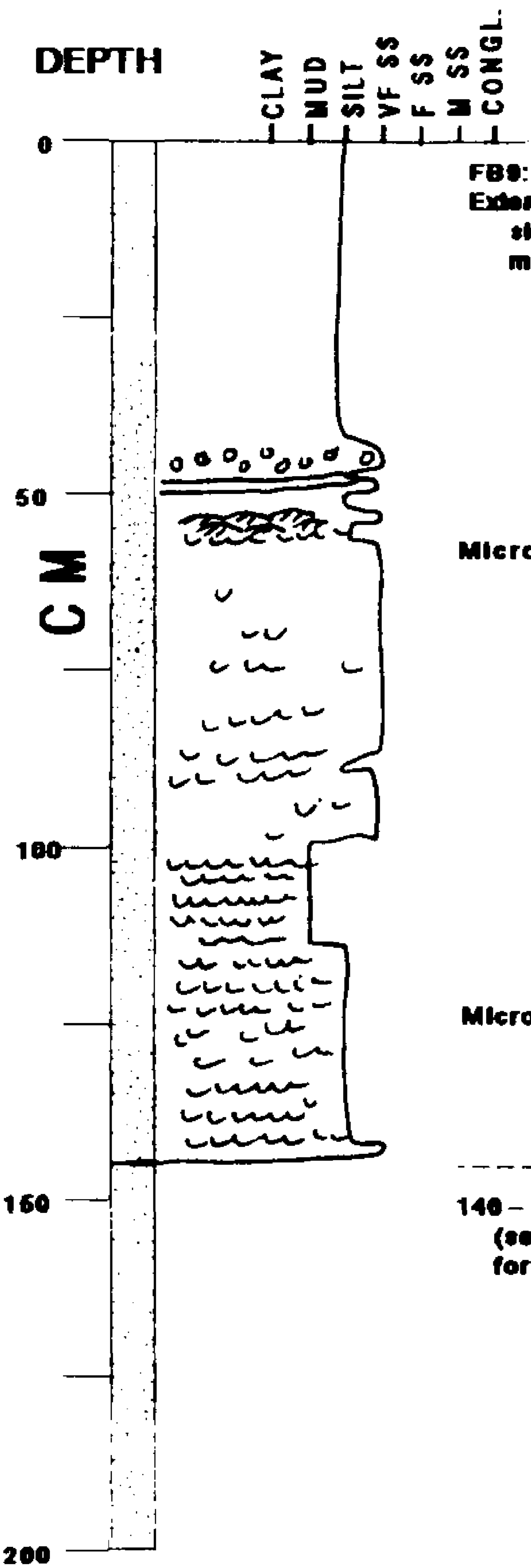
- **extensively burrowed pelletal lithologies**
- **a few rhythmic layers**
- **mudball horizon**
- **large backfilled cross – cutting burrows**

FB4: pelletal clay

EXPANDED LOG

CORE NO: 47

PROFILE: D
7.5 MIN QUAD: ERWINVILLE, LA
ELEVATION ABOVE M.S.L.: 35 ft.



FB9:
Extensively mottled silt, very fine sand.
slightly banded
massive appearing

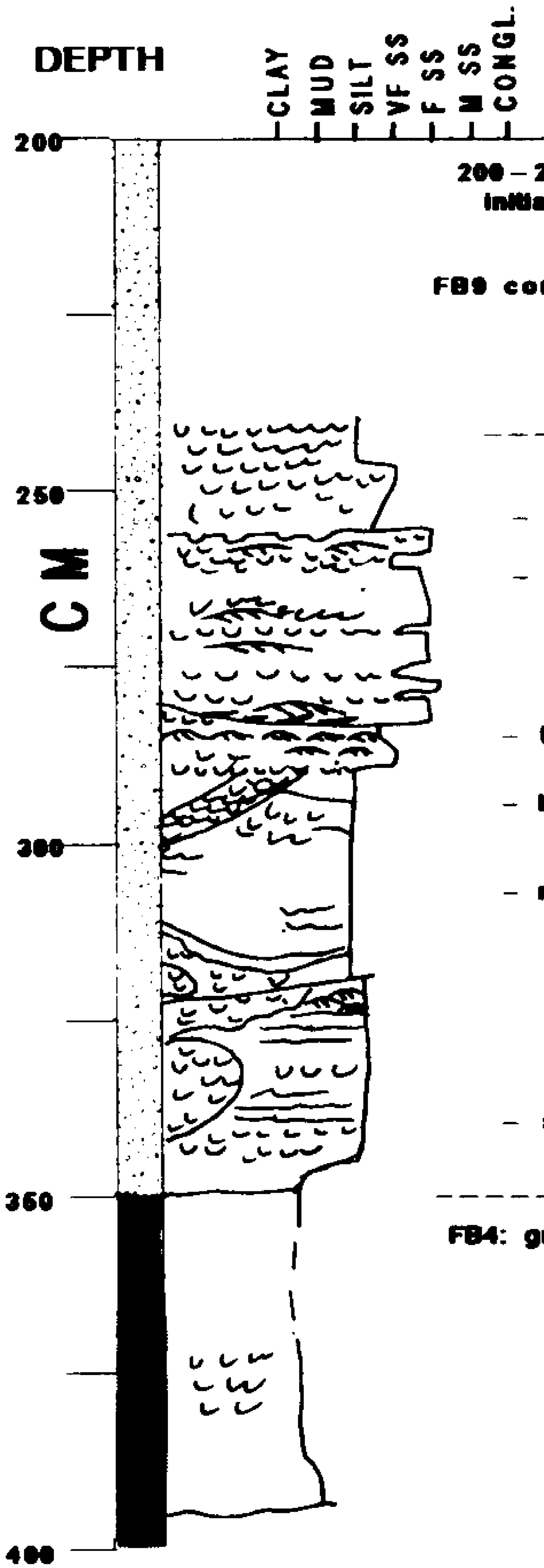
Micropelletal silt

Micropelletal silt

---

140 – 230 cm lost (spilled) after initial log (see previous page) and was not available for a later more detailed analysis.

EXPANDED LOG
CORE NO: 47
PROFILE: D



200 – 230 cm lost from core tube after initial log.

FB9 continued

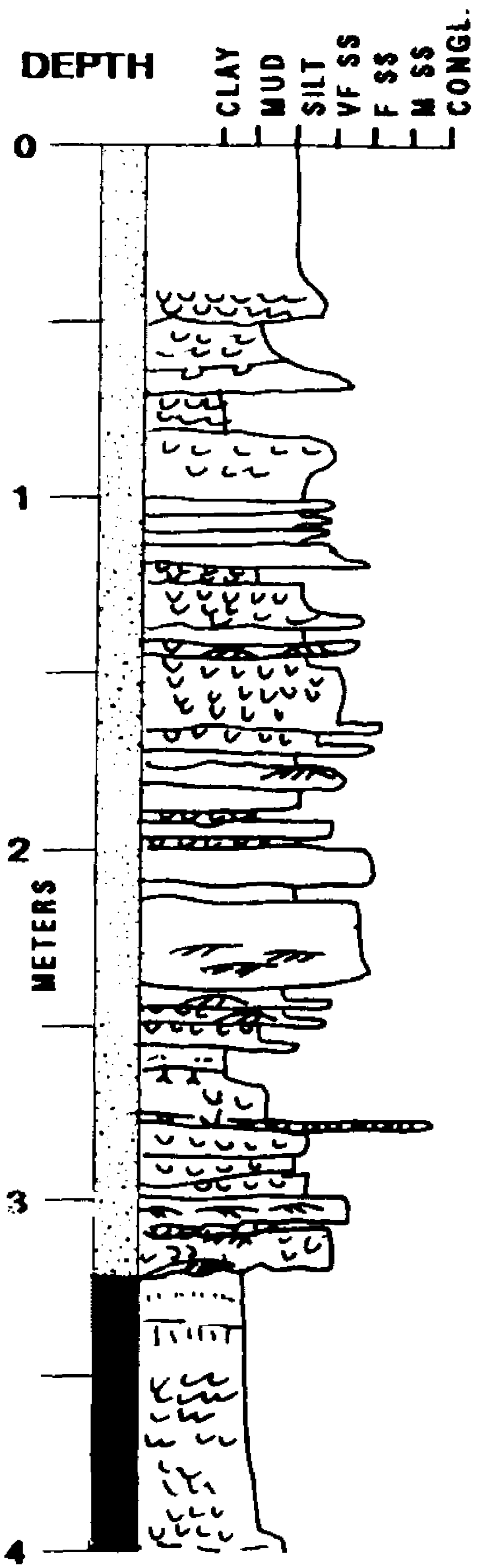
- alternating layers of pelletal silt, pelletal clayey silt and ripple – laminated sand.
- burrowing is disruptive to primary stratification

- trough cross stratification

- burrow filled with white, well – sorted sand which has mudballs or pellets along horizontal layers
- micropelletal clayey silt

- silt and mud laminations

FB4: gray pelletal mud



CORE NO: 48

PROFILE: D

7.5 MINUTE QUAD: ERWINVILLE, LA

ELEV. ABOVE M.S.L: 35 ft.

TEXT FIGURES: 30

FB9:

- **clayey very fine sand and silt**
- **slightly clayey very fine sand**
- **pelletal mud**
- **pelletal clay**
- **irregularly layered**
- **micropelletal mud**
- **pelletal sand and silt**
- **ripple laminations**
- **cross – stratified sand with clay drapes separating sets**
- **ripples in silty rhythmites**
- **micropelletal clayey silt**
- **burrowed, cross – stratified**
- **scour at basal contact**

FB4:

- **Fe – oxides, coated root hairs or leaf fronds**
- **micropelletal mud**

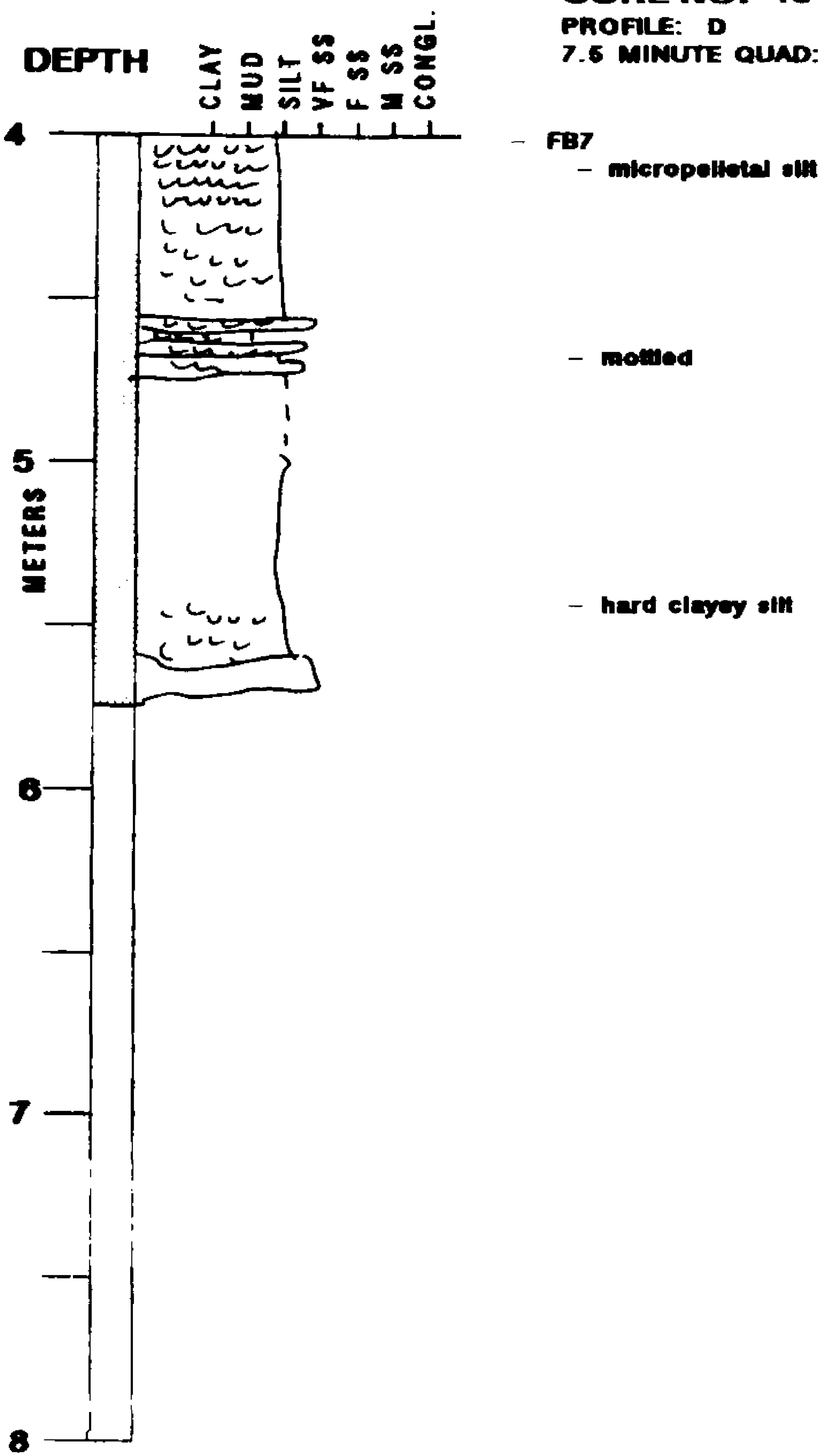
FB8: dark brown pelletal mud

Continued

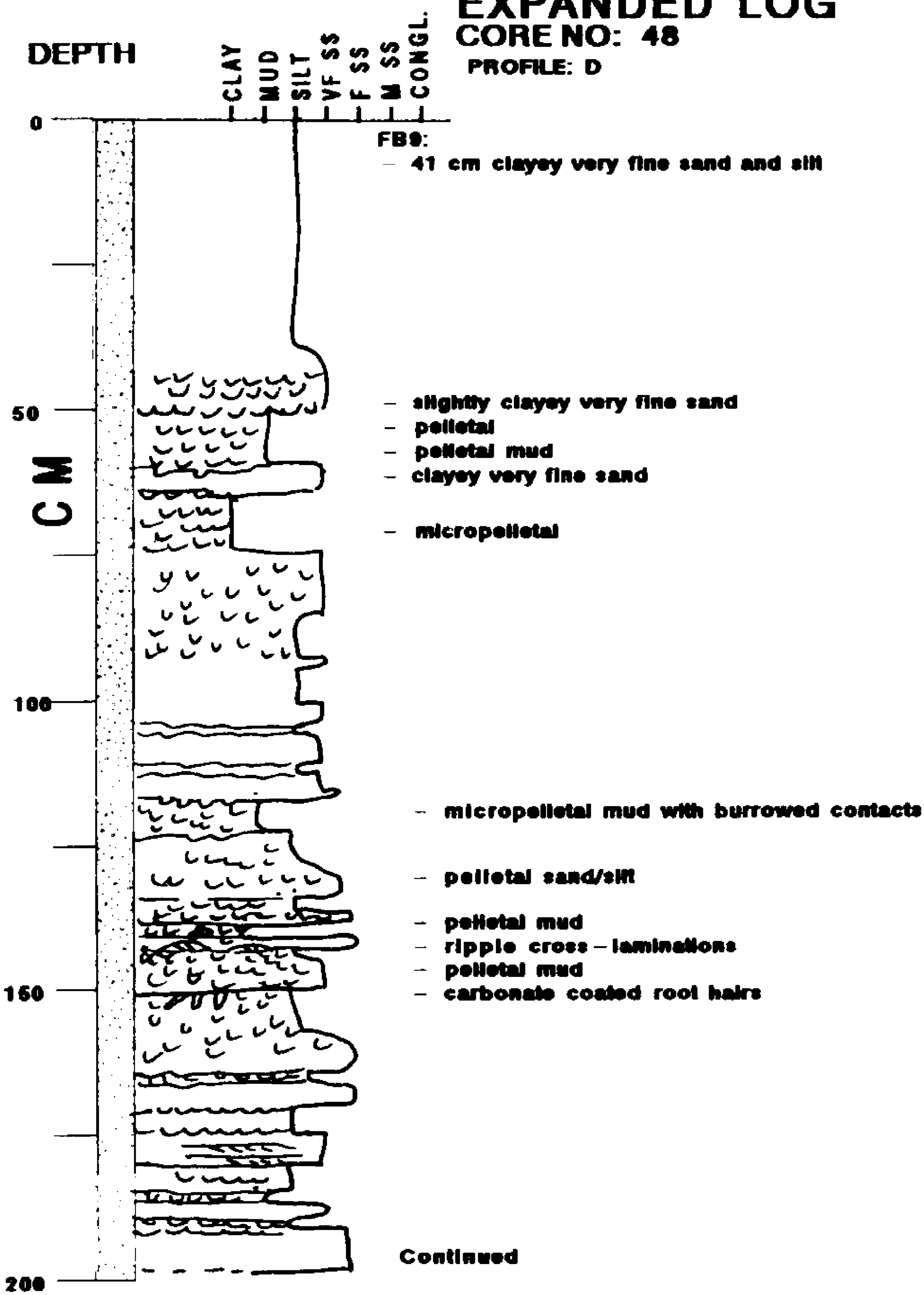
CORE NO: 48 continued

PROFILE: D

7.5 MINUTE QUAD: ERWINVILLE, LA



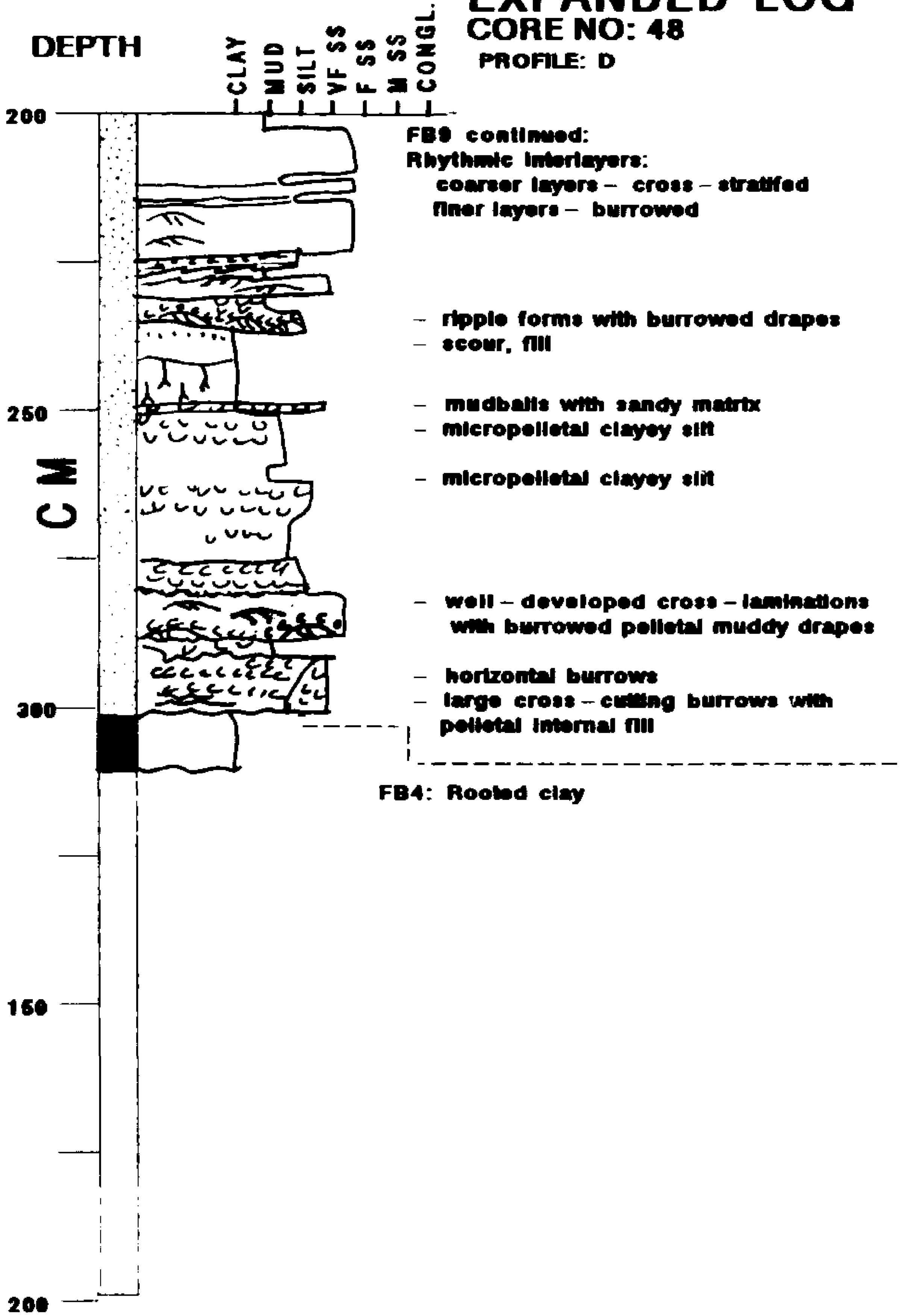
EXPANDED LOG
CORE NO: 48
PROFILE: D



EXPANDED LOG

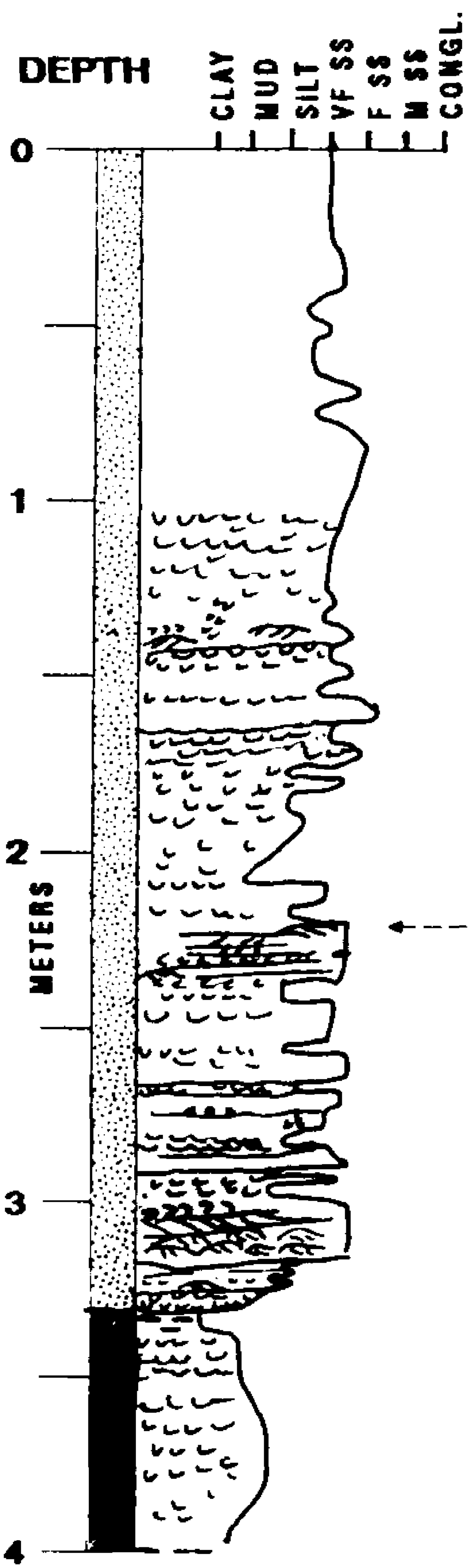
CORE NO: 48

PROFILE: D



CORE NO: 49

PROFILE: C
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 36 FT
TEXT FIGURES: 36, 37



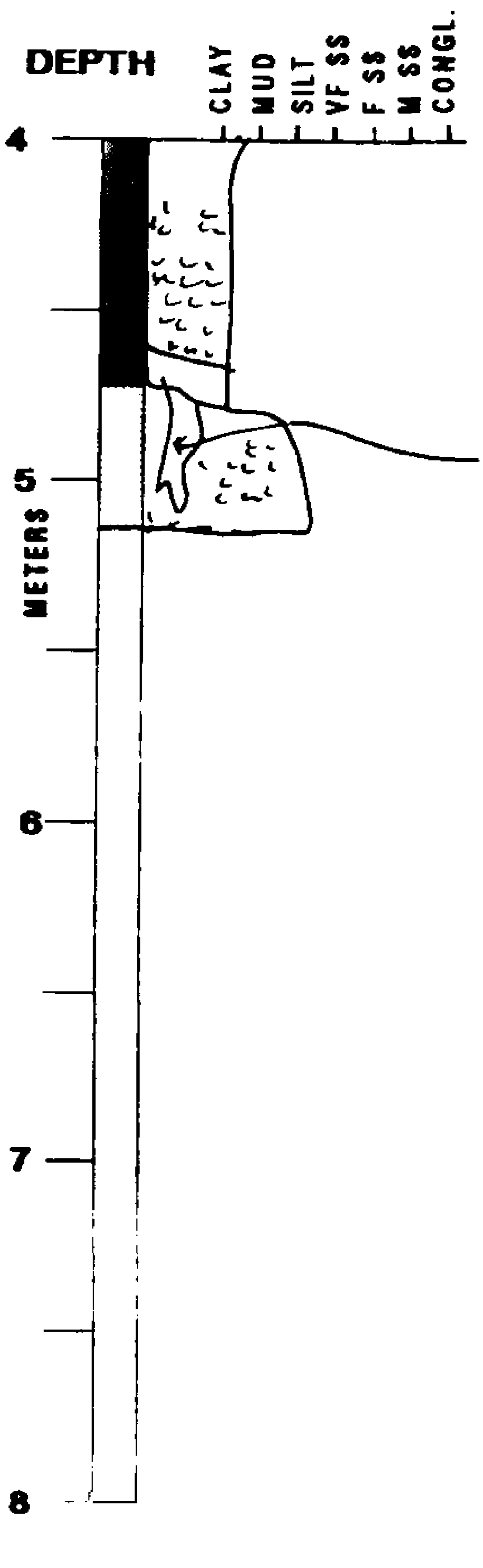
FB9:
- slightly banded very fine sand
- mud – rich bands
- pelletal sand
  trace of layering or banding
- various pelletal lithologies
- well – sorted sand
- poorly sorted silty sand
- sandy, clayey silt, poorly sorted
- well – preserved primary stratification
  begins here
- parallel laminations
- planar? with small – scale troughs
- burrowed silty rhythmites with
  burrowed mud drapes
- clayey silt

FB4: pelletal mud with
granular Fe – oxides associated
with pelletal fabric

CORE NO: 49 continued

PROFILE: C

7.5 MINUTE QUAD: ERWINVILLE, LA



FB4: continued
Gray clay with granular Fe – oxides associated with pelletal fabric

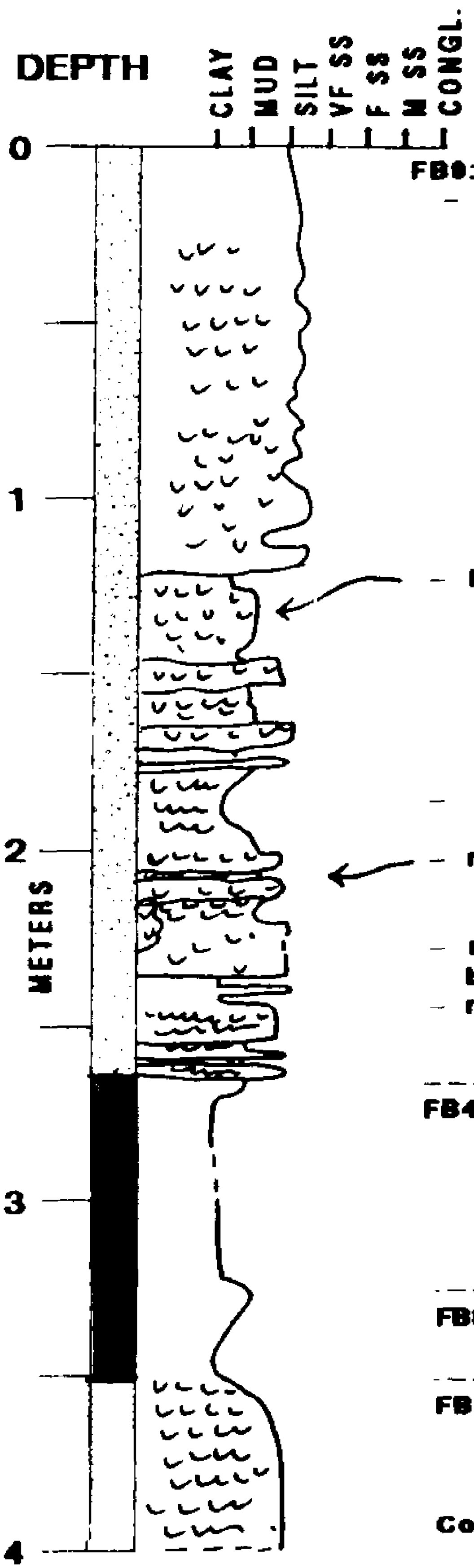
---

FB8: dark brown pelletal clay

FB7:
- large burrow containing fine sand clay balls (ripups)
- very fine clayey sand

CORE NO: 52

PROFILE: E
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 31 FT.
TEXT FIGURES: 39



FB9:
- **Extensively burrowed micropelletal silt**
- **interbedded pelletal silt and pelletal mud**
- **brown pelletal mud**
- **rhythmically layered pelletal mud and silt**
- **micropelletal silt with large crosscutting burrows**
- **rhythmically layered silt and clayey silt**

FB4: Brownish gray clay

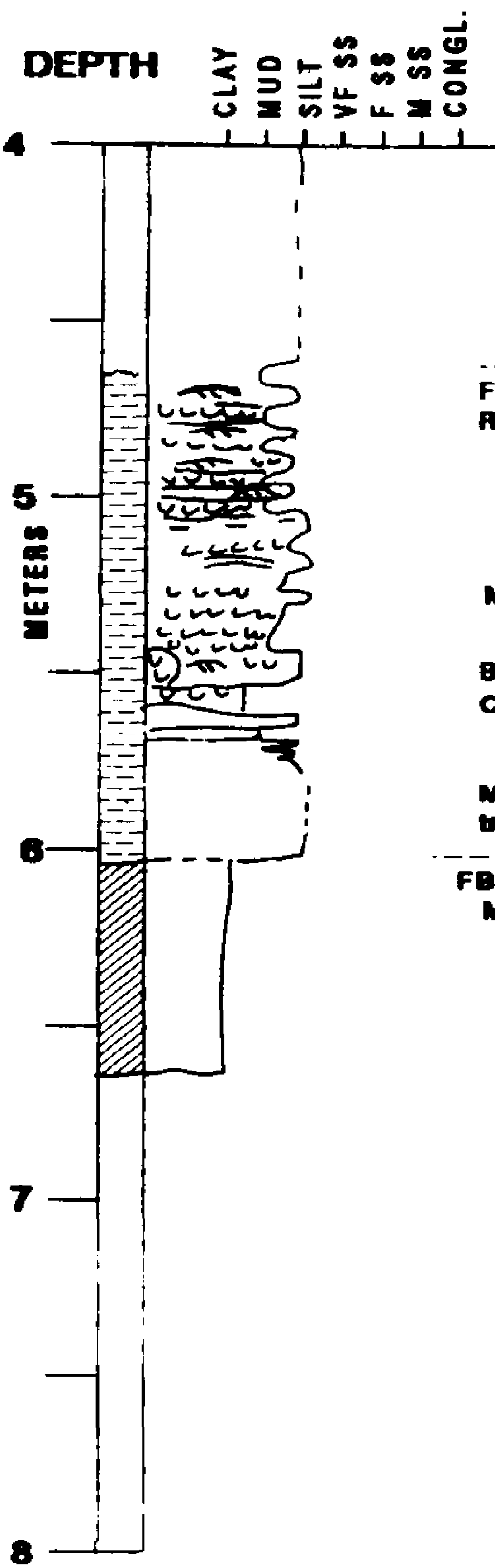
FB8: dark brown mud and clay

FB7: micropelletal silt, hard fine – grained

Continued

CORE NO: 52 continued

PROFILE: E
7.5 MINUTE QUAD: ERWINVILLE, LA



FB7 CONTINUED
– SLUMPED PELLETAL SILT

FB6:
Rhythmically layered silt and mud
– burrowed
– with traces of small ripple laminations

Micropelletal silt

Burrowed silt with trace of cross – laminations
Clay with silty layers

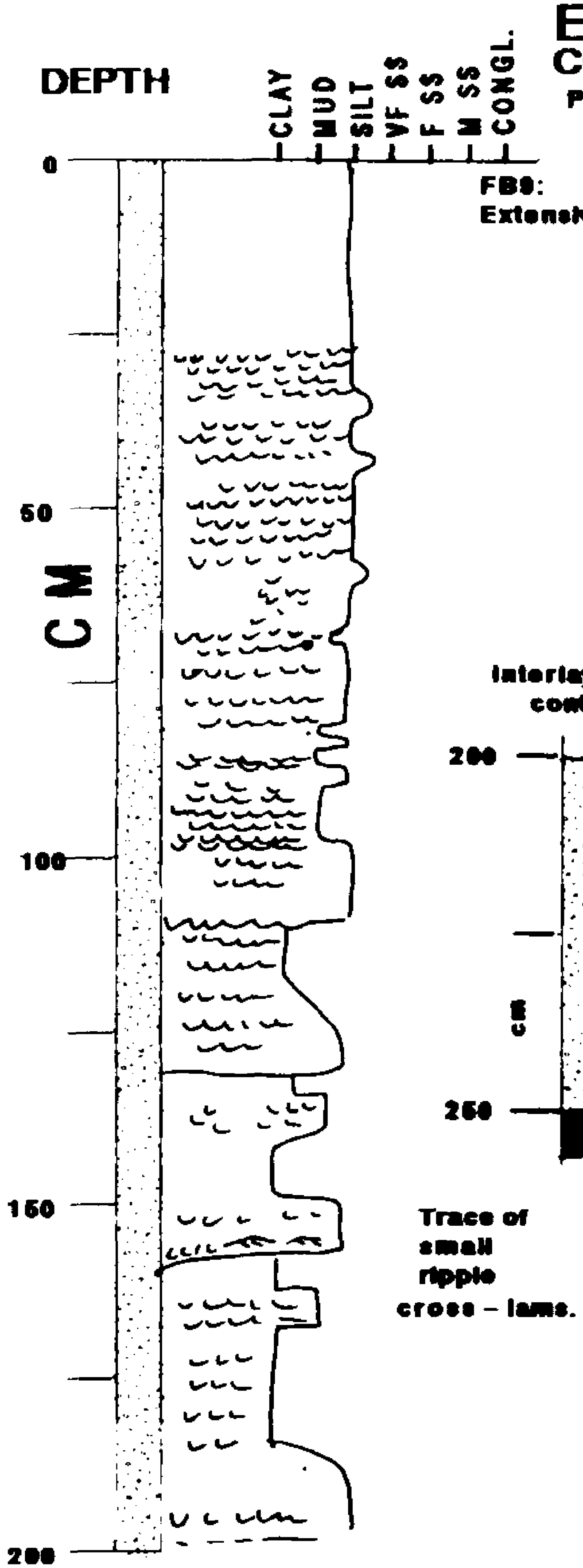
Micropelletal silt
trace of silty rhythmites

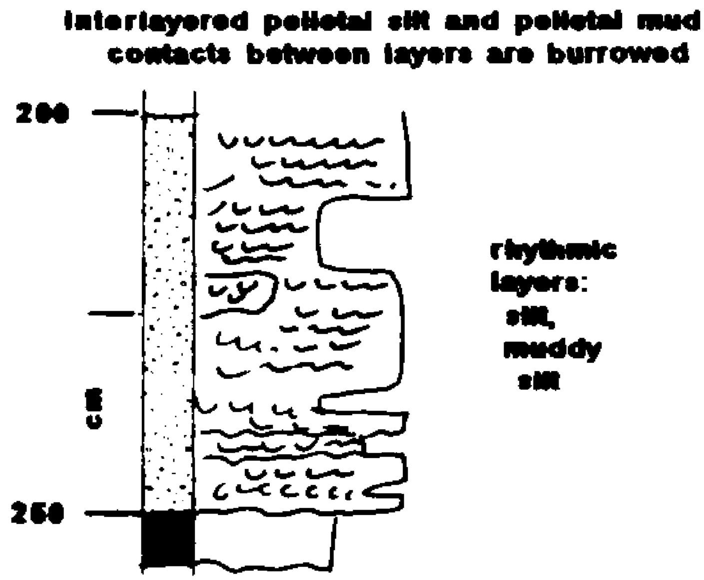
FB5:
Micropelletal clay with trace of rhythmic layering

EXPANDED LOG

CORE NO: 52

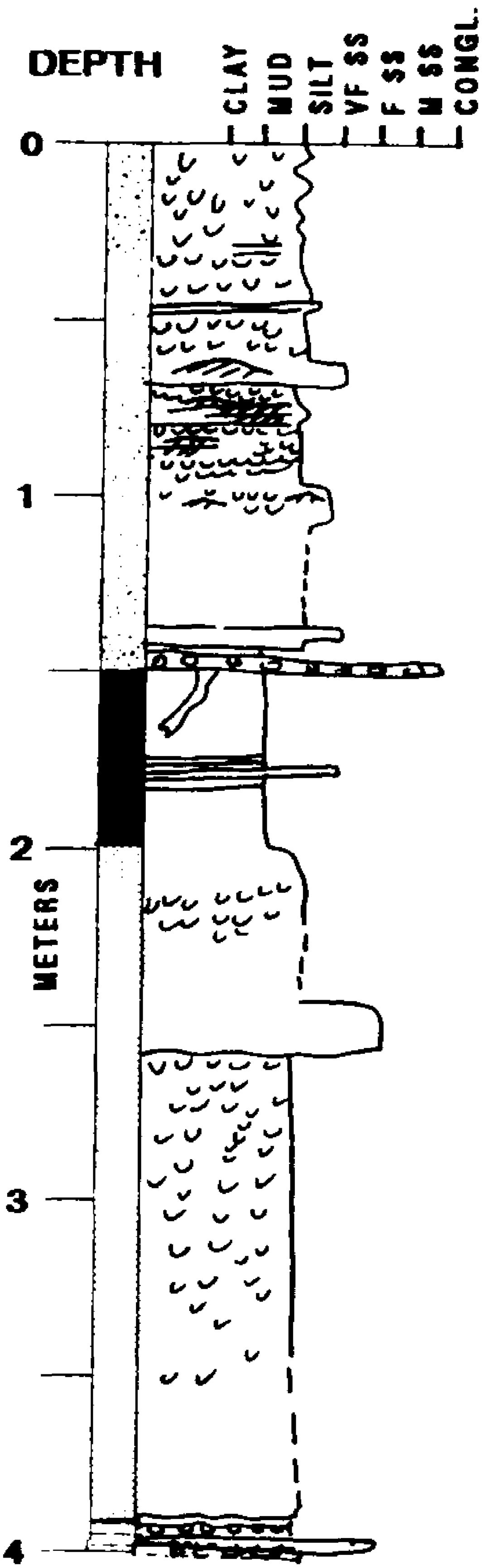
PROFILE: E





CORE NO: 53

PROFILE: F
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 30 FT.
TEXT FIGURES: 30



FB9
Rhythmic layering with traces of primary stratification
(see EXPANDED LOG)

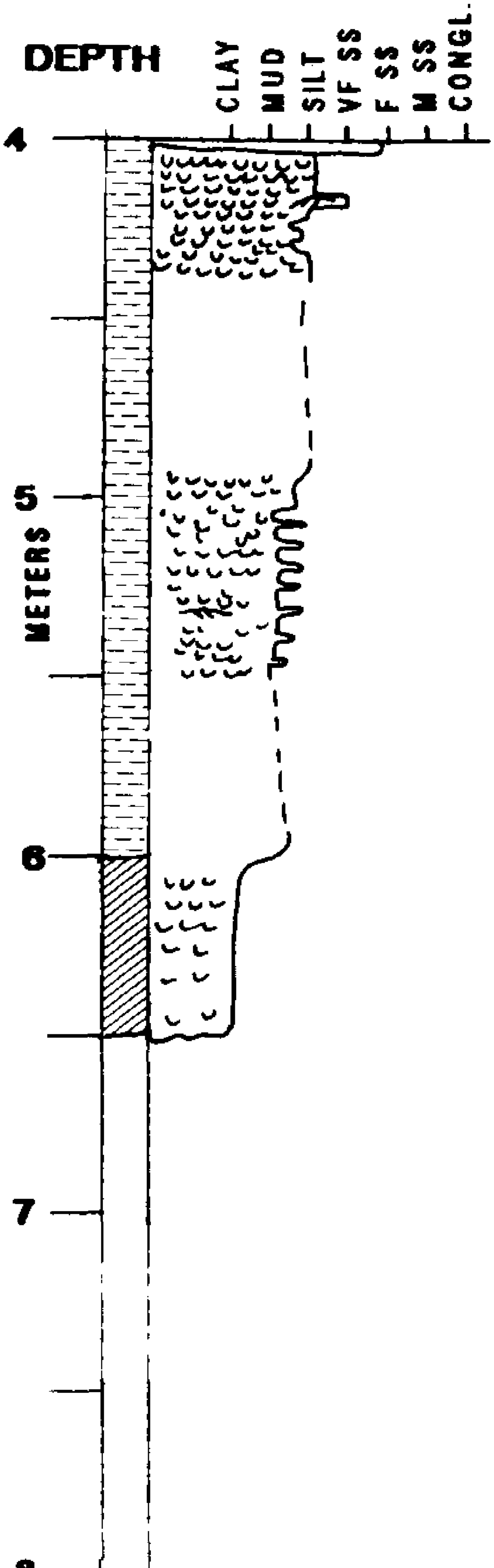
– mudballs in silt matrix

FB4: Rooted clay

FB8: dark brown laminates
dark brown organic – rich mud

FB7: hard clayey micropelletal silt

FB6: Rhythmically layered mud, banded
Continued



CORE NO: 53 continued

PROFILE: E

7.5 MINUTE QUAD: ERWINVILLE, LA

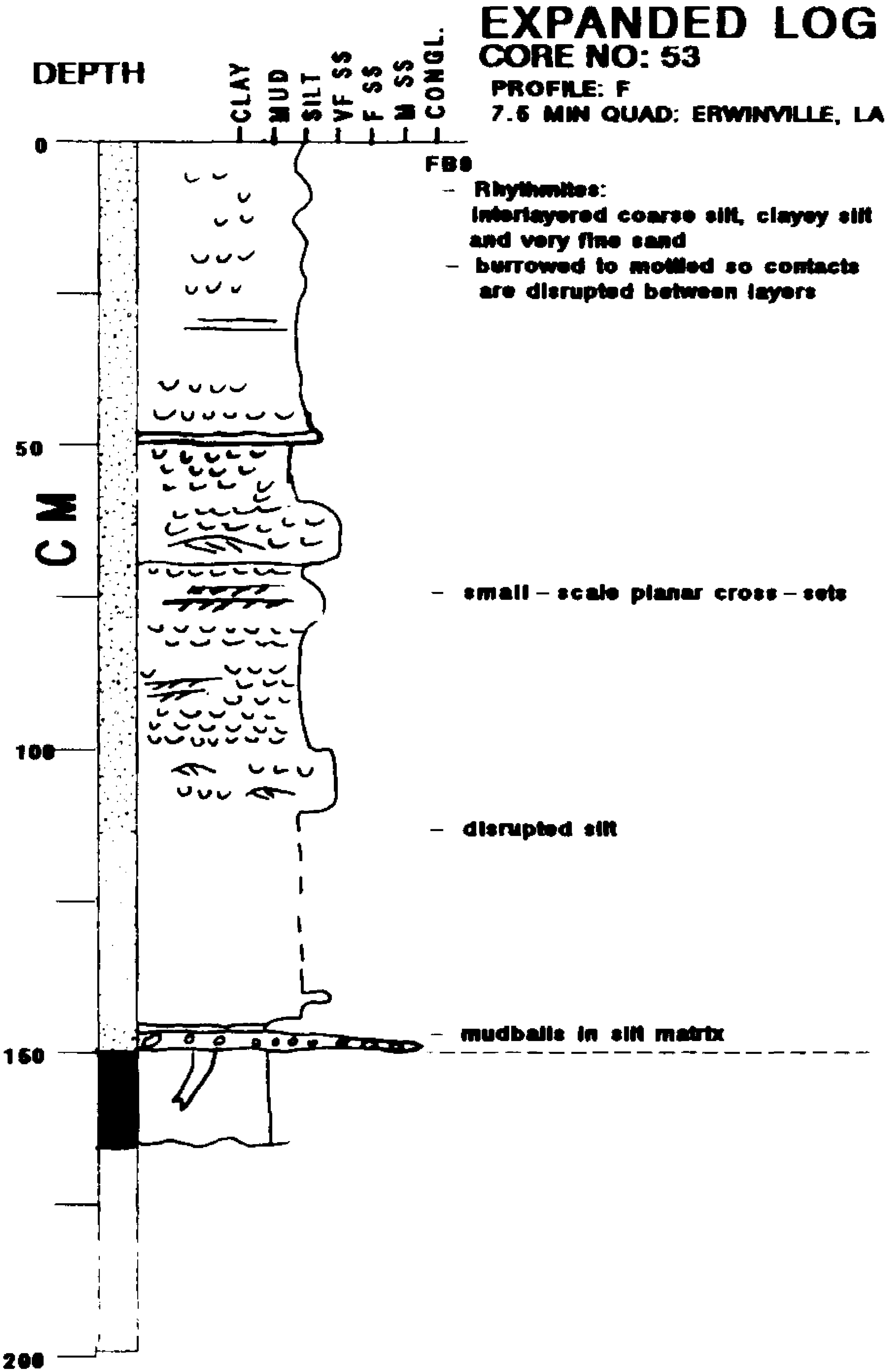
FB6 Continued

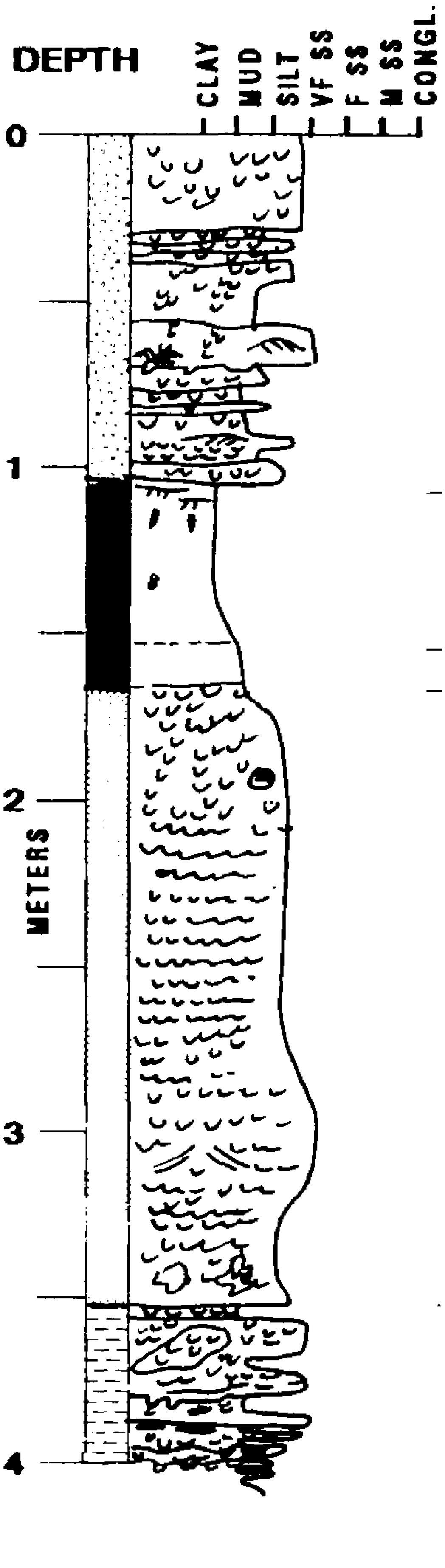
- muddy rhythmites
  banded, micropelletal

- micropelletal, rhythmically interlayered
  mud and silt
  silt is present as burrowed laminations

FB5:

- dark gray clay, silty
  micropelletal
  vivianite(?) nodules


EXPANDED LOG
CORE NO: 53
PROFILE: F
7.5 MIN QUAD: ERWINVILLE, LA
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
C M
0
50
100
150
200
FB9
Rhythmites:
interlayered coarse silt, clayey silt and very fine sand
burrowed to mottled so contacts are disrupted between layers
small - scale planar cross - sets
disrupted silt
mudballs in silt matrix



CORE NO: 54

PROFILE: F
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 29 FT.
TEXT FIGURES: 30, 35, 38, 39, 40, 51

FB9:
- sand, muddy, very fine, mottled
- micropelletal sand and mud
- large crosscutting burrows
- micropelletal silt and mud
- traces of small – scale trough cross – sets

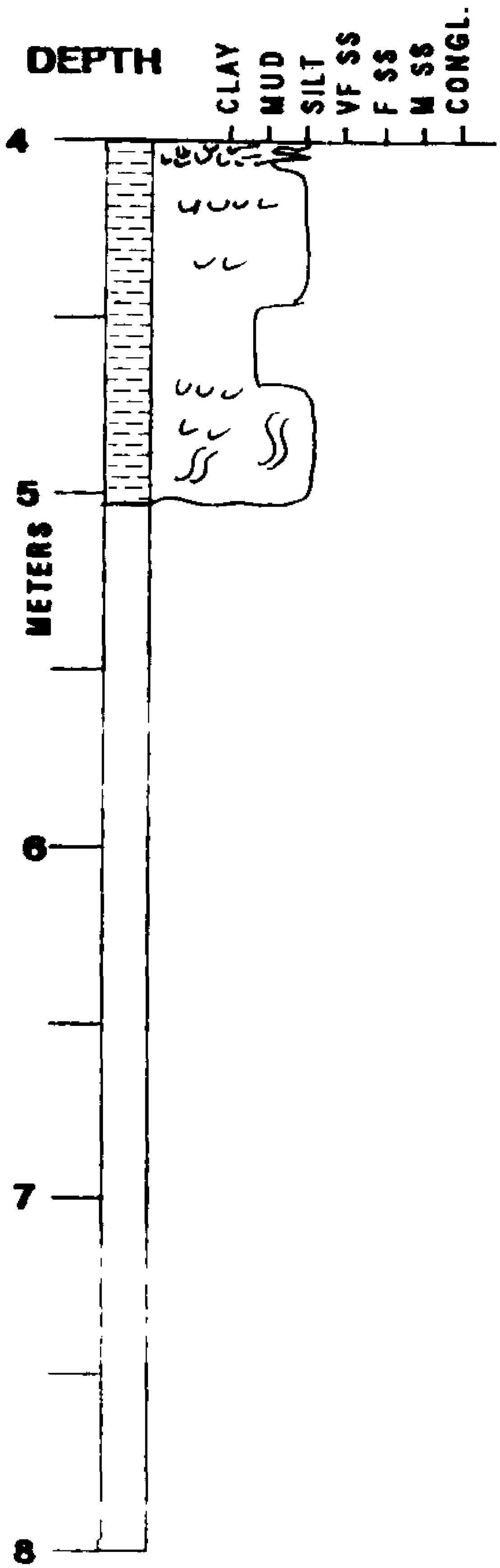
FB4: Rooted clay
- carbonated coated leaf fronds
- coated vertical root hairs
- silt – rich mottles

FB8: dark brown organic – rich mud

FB7: yellowish sandy mud and muddy sand
- geopetally infilled root burrow
-
- Micropelletal silt, slightly clayey
  primary stratification consisted of
  minute laminations
- granular Fe – oxides associated with
  pelletal fabric
- micropelletal lithologies

FB6: Well – stratified rhythmites
- lenticular bedding
  alternating pelletal mud and silt layers
  traces of parallel laminations

Continued



CORE NO: 54 continued

PROFILE: F
7.5 MINUTE QUAD: ERWINVILLE, LA

FB6 continued:
Rather disrupted pelletal silt
(due to coring?)

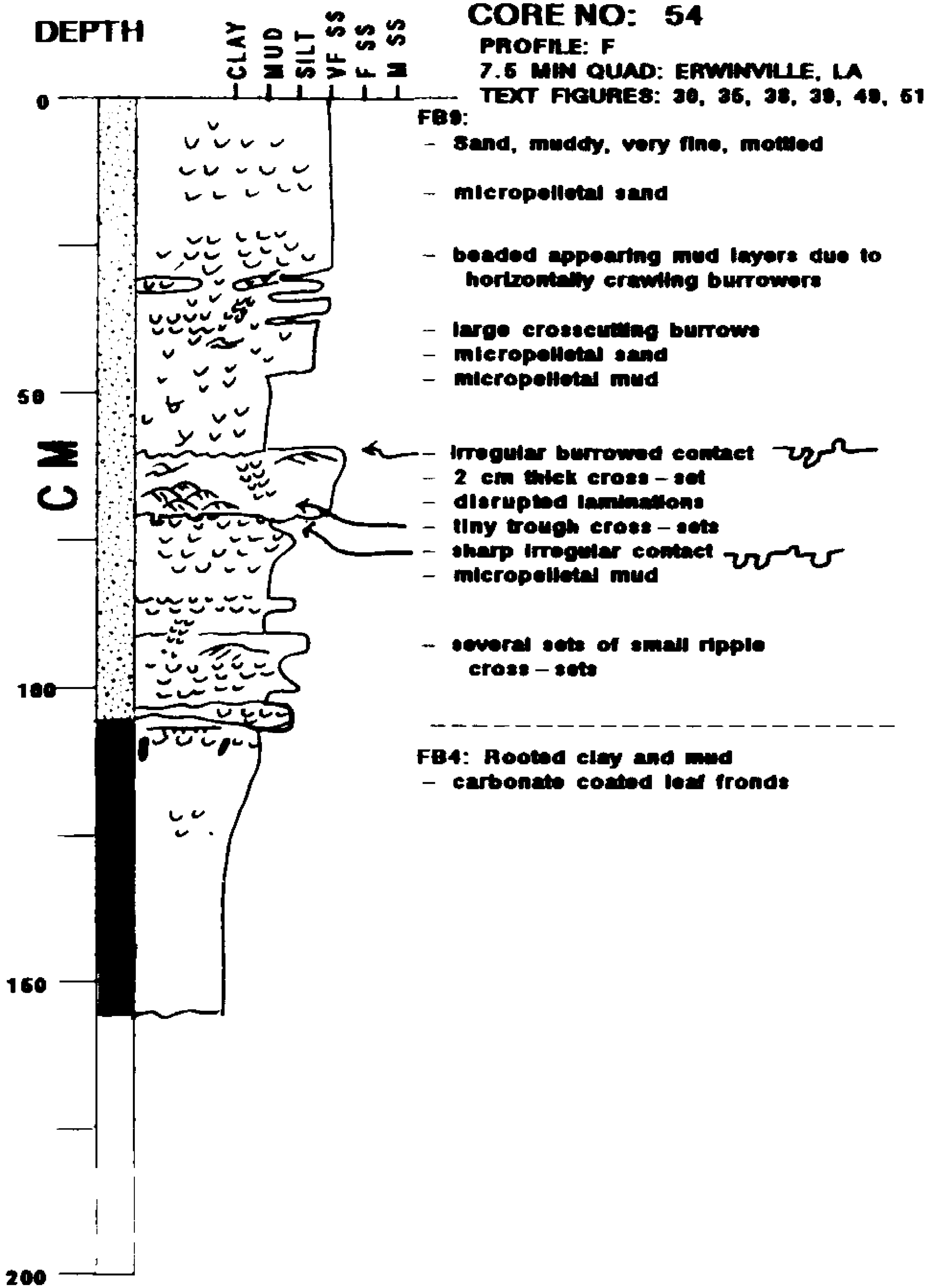
EXPANDED LOG

CORE NO: 54

PROFILE: F

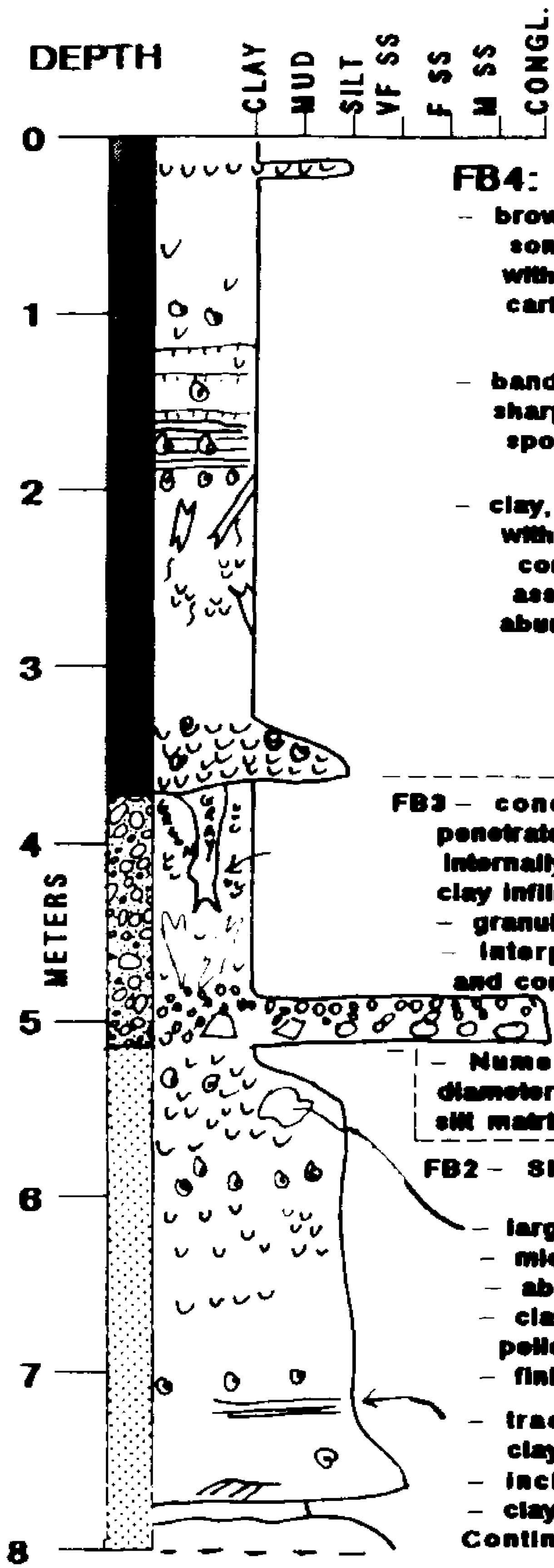
7.5 MIN QUAD: ERWINVILLE, LA

TEXT FIGURES: 30, 35, 38, 39, 49, 51



CORE NO: 63

PROFILE: A
7.5 MINUTE QUAD: MORGANZA, LA
ELEV. ABOVE M.S.L: 23 FT
TEXT FIGURES: 22



FB4:

- brownish – gray clay – some granular Fe – oxides associated with pelletal fabric, sporadic carbonate nodules.
- banded red and gray clay (26 cm thick) sharp boundaries between layers, sporadic carbonate nodules
- clay, gray (63 cm) with giant root mottles, carbonate concretions, granular Fe – oxides associated with pelletal fabric abundant vertical root hairs.

FB3 – concretion – rich yellowish – green clay, penetrated by large root burrows which internally lack concretions and have a gray clay infill.

- granular Fe – – oxides in pelletal fabric
- interpenetrating lithologies (concretion – rich and concretion – free clay) start here.

- Numerous granule – sized mudchips (3 mm in diameter); mudballs of varying lithologies with a silt matrix; green, pink and gray clay balls.

FB2 – Silt, clayey, greenish – gray with orange mottling.

- large mud – filled burrows or root traces
- micaceous, sandy
- abundant concretions
- clayey silt is hard, micromottled into a pelletal fabric
- fining upward at top of unit into clay
- trace of laminations in hard, slightly clayey silt
- inclined laminations
- clayey silt

Continued on next page

CORE NO: 63 continued

PROFILE: A
7.5 MINUTE QUAD: MORGANZA, LA

FB2 – continued

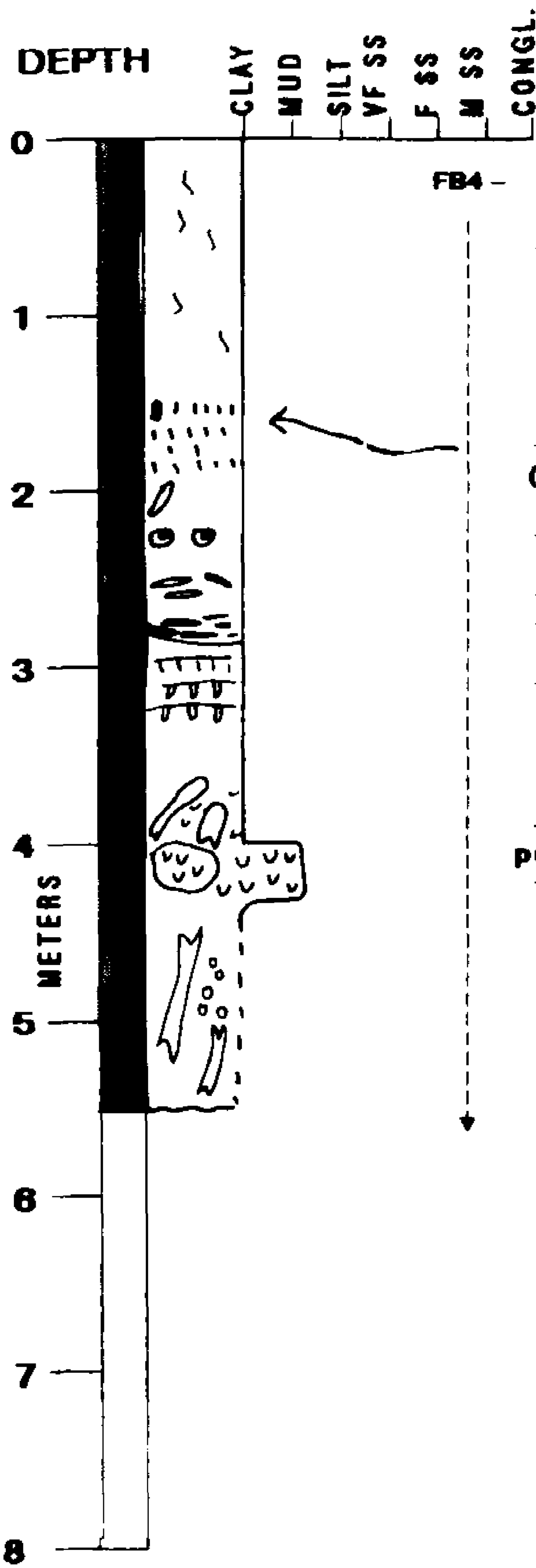
– disrupted laminations in silt

FB1 – dark blue clay, silty with distinctly coated root hairs

Lowest 3 meters of this core is extremely poorly preserved except for lower half of each core tube. Details of stratification are obscured. But contacts beween are quite accurate.

CORE NO: 64

PROFILE: A
7.5 MINUTE QUAD: MORGANZA, LA
ELEV. ABOVE M.S.L: 23.5 FT
TEXT FIGURES: 22

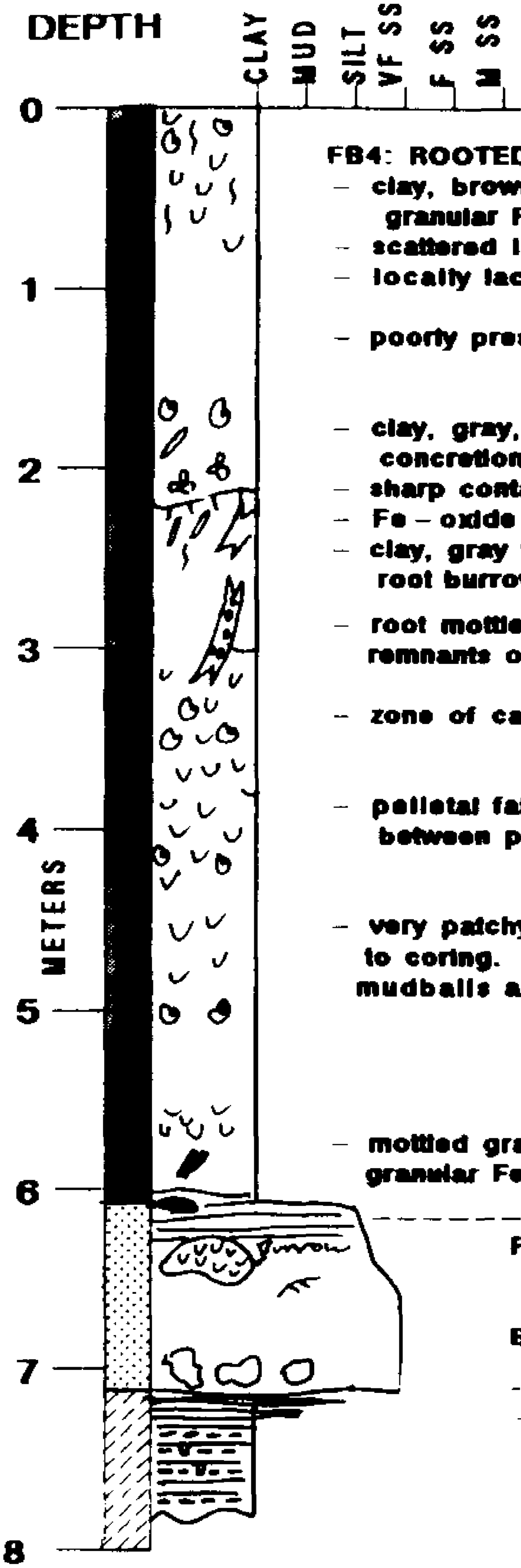


FB4 – ROOTED CLAY

- thin root linings
- carbonate coated leaf fronds
(appear as reticulate network of tiny rods in X – ray radiographs)
- smooth gray clay and clay full of concretions
- larger coated roots (1 – 2 mm diameter)
- rare occurrence of leaves and wood as discrete irregular layers
- upward termination of coated root hairs along horizons
- large root mottles (gray clay within mottle, pelletal green clay outside mottle)
- pelletal silt with clay filled burrows
- chaotic – appearing mixed lithologies, still predominantly clay, but expect to encounter mudball conglomerate (FB3) or silt (FB2) at this depth. Consists of greenish gray clay with large clay – filled root mottles, and interpenetrating lithologies. Transition to underlying mudball conglomerate (?) is probably beginning.

CORE NO: 66

PROFILE: A
7.5 MINUTE QUAD: MORGANZA, LA
ELEV. ABOVE M.S.L: 24 FT
TEXT FIGURES: 22, 43



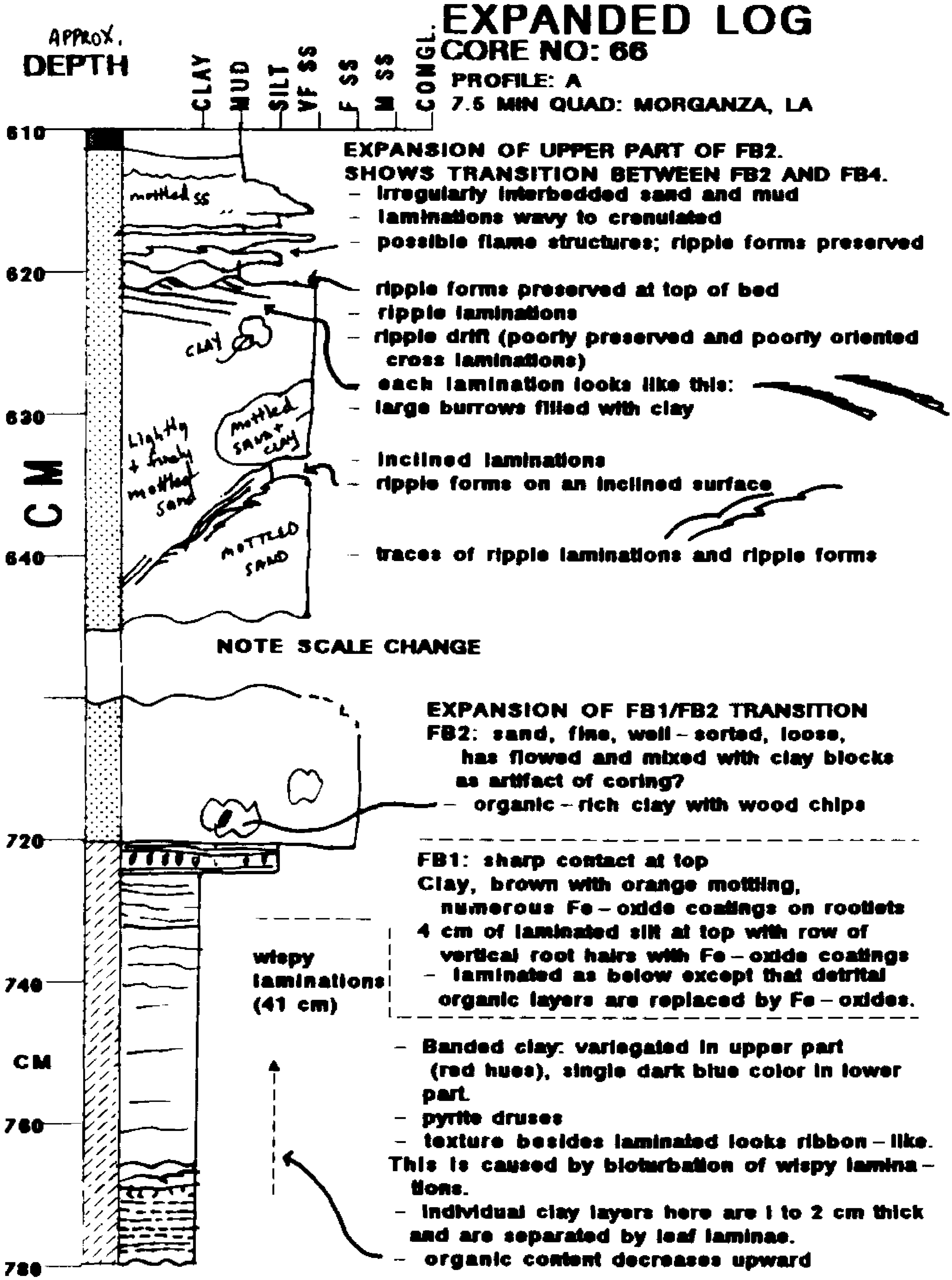
FB4: ROOTED CLAY

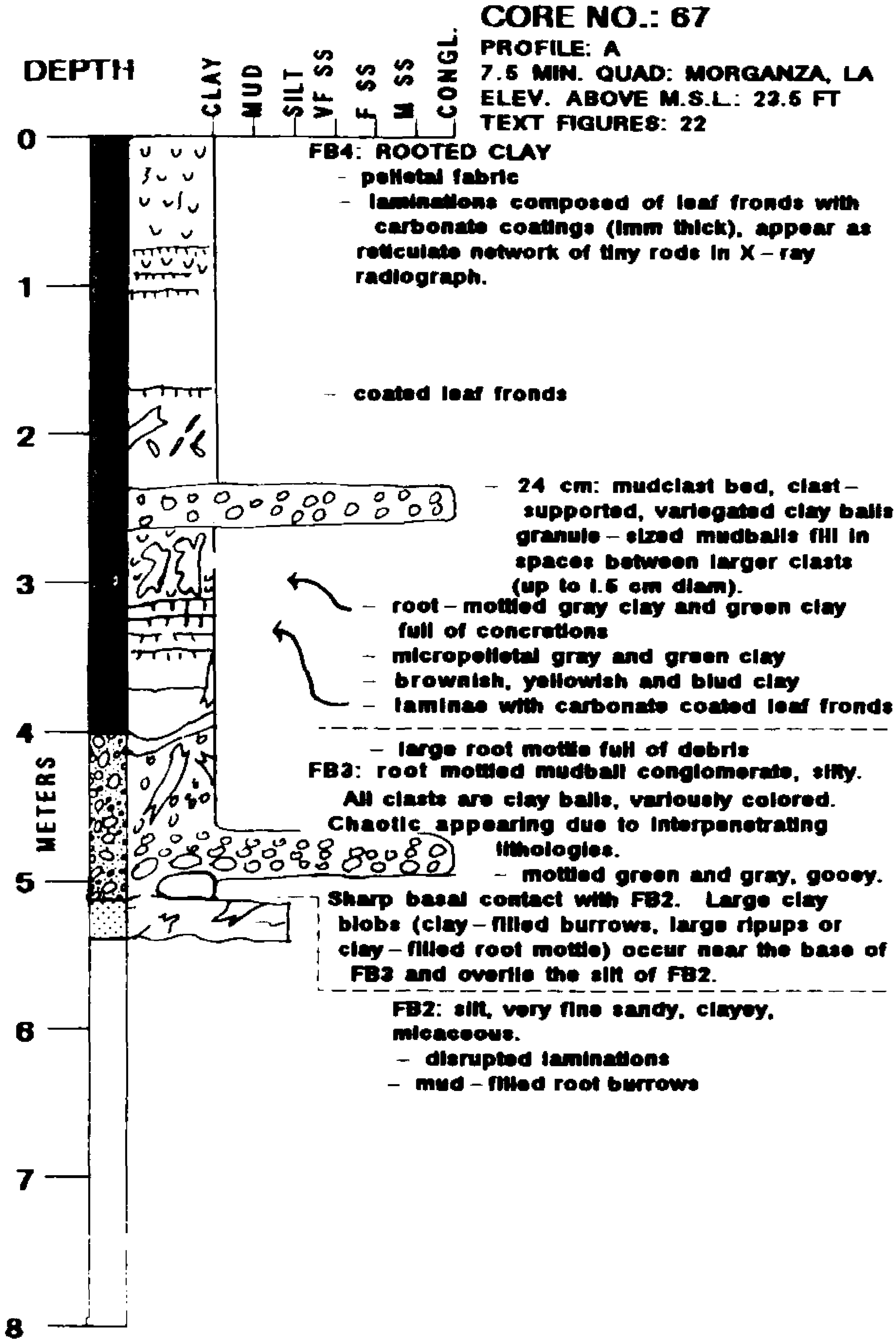
- clay, brownish, gray, with pelletal fabric and granular Fe – oxides in matrix between pellets
- scattered large (1 cm) carbonate nodule
- locally lacks concretions
- poorly preserved, clay dominates
- clay, gray, full of carbonates and Fe – oxide concretions
- sharp contact: probably border of root mottle
- Fe – oxide coated rootlets
- clay, gray with orange mottles, sporadic large root burrows give clay a mottled appearance
- root mottle: internally consists of gray clay with remnants of plant roots and brecciated clay
- zone of carbonate concretions in gray clay
- pelletal fabric with Fe – oxides as granules between pellets
- very patchy lithologies; probably disruption due to coring. Looks like clay is mixed with mudballs and concretions.
- mottled gray and pale green clay with granular Fe – oxides and wood.

FB2: Expanded on next page for details. very fine clayey sand, fines upward into silt, pale yellowish green. Burrowed near top, also laminated, rippled.

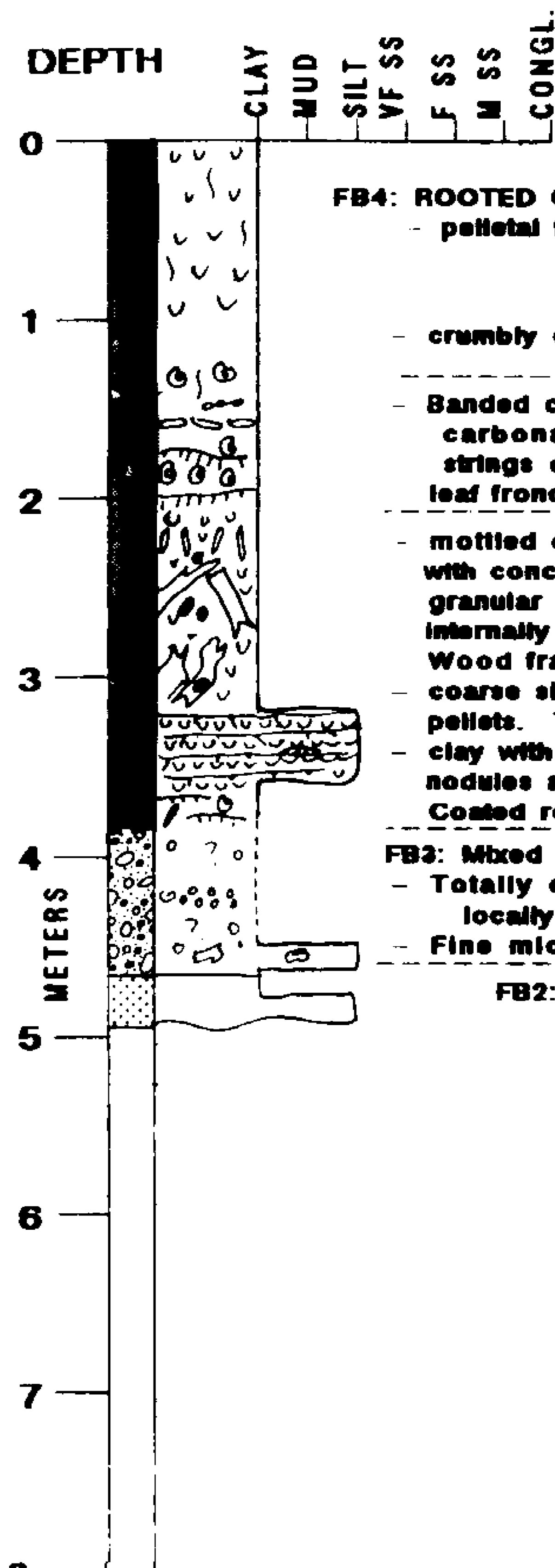
- gradational contact: irregular clay, silt lams

FB1: Clay with leaf laminae, pyrite druses, burrowed wispy disrupted zones, beautifully preserved stratification. Expanded on next page for details.


EXPANDED LOG
CORE NO: 66
PROFILE: A
7.5 MIN QUAD: MORGANZA, LA
APPROX.
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
610
620
630
640
CM
mottled ss
clay
Lightly + finely mottled sand
mottled sand + clay
MOTTLED SAND
EXPANSION OF UPPER PART OF FB2.
SHOWS TRANSITION BETWEEN FB2 AND FB4.
– irregularly interbedded sand and mud
– laminations wavy to crenulated
– possible flame structures; ripple forms preserved
– ripple forms preserved at top of bed
– ripple laminations
– ripple drift (poorly preserved and poorly oriented cross laminations)
– each lamination looks like this:
– large burrows filled with clay
– inclined laminations
– ripple forms on an inclined surface
– traces of ripple laminations and ripple forms
NOTE SCALE CHANGE
EXPANSION OF FB1/FB2 TRANSITION
FB2: sand, fine, well – sorted, loose, has flowed and mixed with clay blocks as artifact of coring?
– organic – rich clay with wood chips
720
740
760
780
CM
FB1: sharp contact at top
Clay, brown with orange mottling, numerous Fe – oxide coatings on rootlets
4 cm of laminated silt at top with row of vertical root hairs with Fe – oxide coatings
– laminated as below except that detrital organic layers are replaced by Fe – oxides.
wispy laminations (41 cm)
– Banded clay: variegated in upper part (red hues), single dark blue color in lower part.
– pyrite druses
– texture besides laminated looks ribbon – like. This is caused by bioturbation of wispy laminations.
– individual clay layers here are 1 to 2 cm thick and are separated by leaf laminae.
– organic content decreases upward


CORE NO.: 67
PROFILE: A
7.5 MIN. QUAD: MORGANZA, LA
ELEV. ABOVE M.S.L.: 23.5 FT
TEXT FIGURES: 22
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
METERS
0
1
2
3
4
5
6
7
8
FB4: ROOTED CLAY
- pelletal fabric
- laminations composed of leaf fronds with carbonate coatings (1mm thick), appear as reticulate network of tiny rods in X-ray radiograph.
- coated leaf fronds
- 24 cm: mudclast bed, clast-supported, variegated clay balls granule-sized mudballs fill in spaces between larger clasts (up to 1.5 cm diam).
- root-mottled gray clay and green clay full of concretions
- micropelletal gray and green clay
- brownish, yellowish and blud clay
- laminae with carbonate coated leaf fronds
- large root mottle full of debris
FB3: root mottled mudball conglomerate, silty. All clasts are clay balls, variously colored. Chaotic appearing due to interpenetrating lithologies.
- mottled green and gray, gooey.
Sharp basal contact with FB2. Large clay blobs (clay-filled burrows, large ripups or clay-filled root mottle) occur near the base of FB3 and overlie the silt of FB2.
FB2: silt, very fine sandy, clayey, micaceous.
- disrupted laminations
- mud-filled root burrows

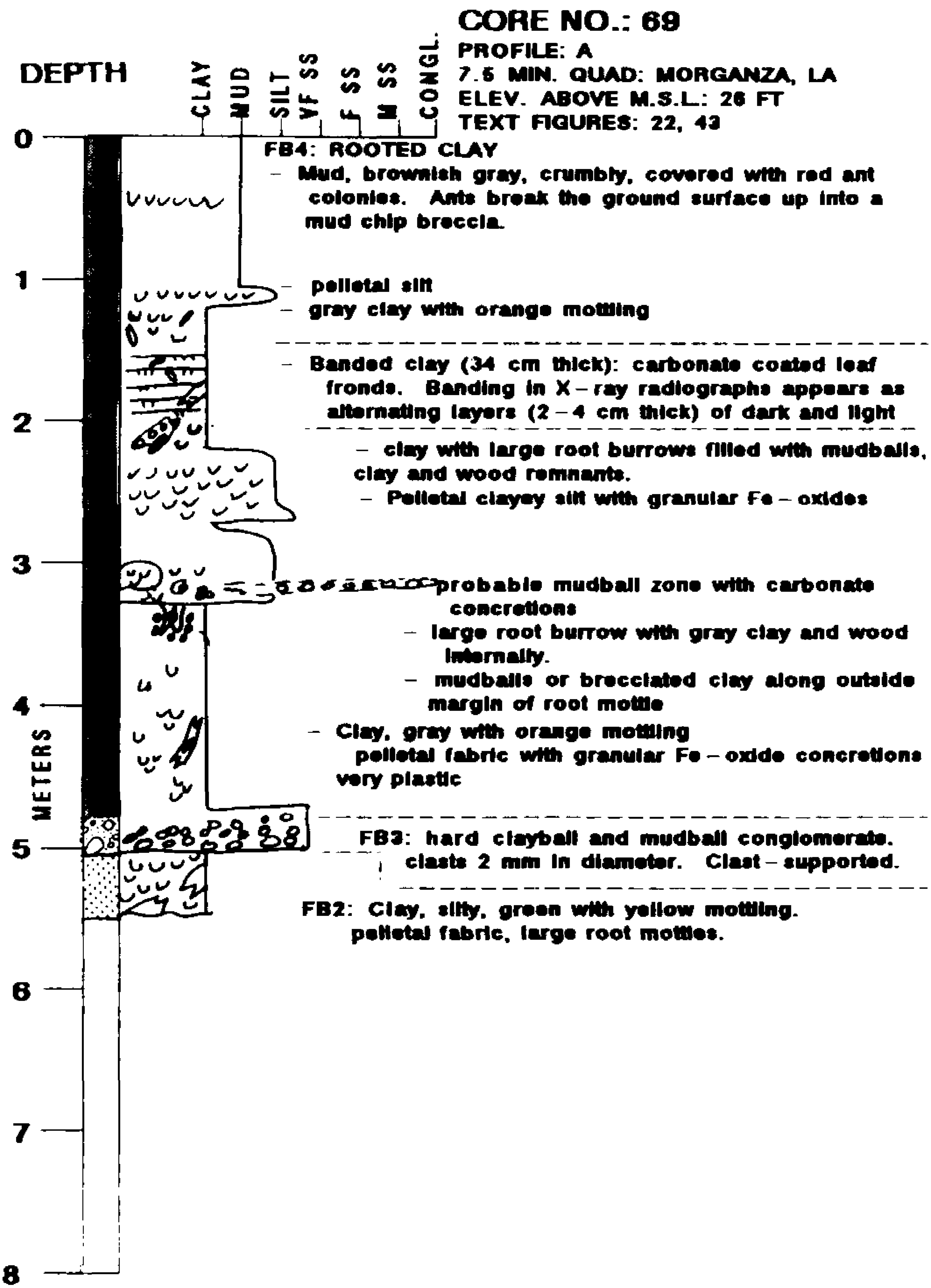
CORE NO.: 68
PROFILE: A
7.5 MIN. QUAD: MORGANZA, LA
ELEV. ABOVE M.S.L.: 23.5 FT
TEXT FIGURES: 22, 42



FB4: ROOTED CLAY
- pelletal fabric with granular Fe – oxides.
- crumbly clay with carbonate concretions
- Banded clay – red and gray, very smooth carbonate nodules concentrated along horizons. strings of carbonate nodules have nucleated on leaf fronds.
- mottled clay: smooth concretion – free clay mixed with concretion – rich clay. Pelletal fabric with granular Fe – oxides as indicated. Root mottles internally consist of the concretion free clay. Wood fragments as indicated.
- coarse silt, very fine sand: pelletal with muddy pellets. Trace of cross – laminations.
- clay with carbonate coated leaf fronds. Carbonate nodules along fronds are as large as I cm in diam. Coated root hairs. Clay is bluish – green.

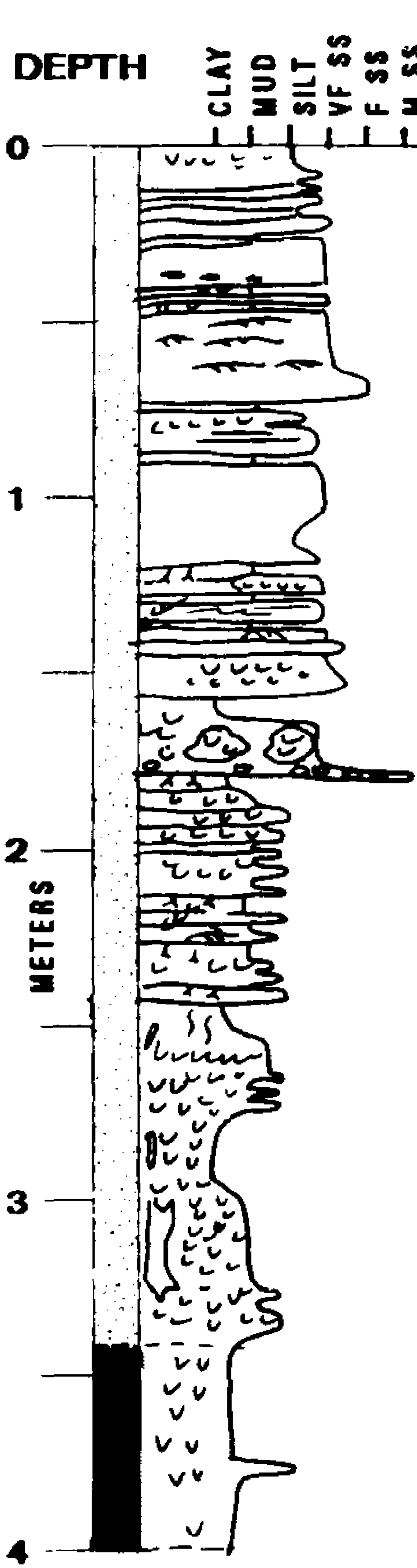
FB3: Mixed clay and clayey sandy silt, wet, pale green.
- Totally chaotic and interpenetrating lithologies: locally silty sand and mudballs.
- Fine micaceous sand, conglomeratic

FB2: Hard, slightly clayey silt with clay mottles.


CORE NO.: 69
PROFILE: A
7.5 MIN. QUAD: MORGANZA, LA
ELEV. ABOVE M.S.L.: 26 FT
TEXT FIGURES: 22, 43
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
1
2
3
4
5
6
7
8
METERS
FB4: ROOTED CLAY
– Mud, brownish gray, crumbly, covered with red ant colonies. Ants break the ground surface up into a mud chip breccia.
– pelletal silt
– gray clay with orange mottling
– Banded clay (34 cm thick): carbonate coated leaf fronds. Banding in X – ray radiographs appears as alternating layers (2 – 4 cm thick) of dark and light
– clay with large root burrows filled with mudballs, clay and wood remnants.
– Pelletal clayey silt with granular Fe – oxides
probable mudball zone with carbonate concretions
– large root burrow with gray clay and wood internally.
– mudballs or brecciated clay along outside margin of root mottle
– Clay, gray with orange mottling
pelletal fabric with granular Fe – oxide concretions
very plastic
FB3: hard clayball and mudball conglomerate. clasts 2 mm in diameter. Clast – supported.
FB2: Clay, silty, green with yellow mottling. pelletal fabric, large root mottles.

CORE NO: 72

PROFILE: B
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 37 FT
TEXT FIGURES: 22, 38, 49, 54



FB9:

- well – sorted laminated sand alternating with clay drapes.
- detrital organics
- planar cross – sets 1 cm thick. very low angle cross – laminations clay drapes separate sets.
- laminated sand layers
- large cross – cutting burrows with pelleted internal fill
- mottled, hard, poorly sorted muddy sand, pelletal.
- mudballs
- pelletal mud and silt with rooted zones at top of fining upward cycles.
- clayey silt, slightly sandy, pelletal with granular Fe – oxides
- dark brown mud with sandy mottles micropelletal
- micropelletal mud, mottled appearing with granular Fe – oxides

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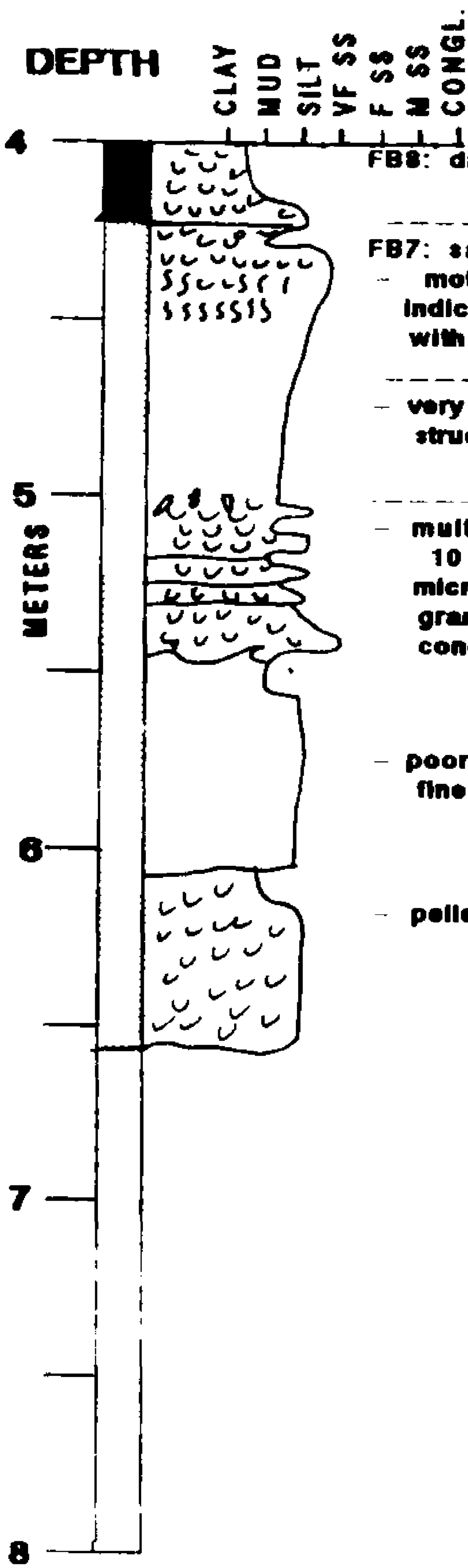
FB4: micropelletal clay, gray to brown

CONTINUED

CORE NO: 72 continued

PROFILE: b
7.5 MINUTE QUAD: ERWINVILLE, LA



FB8: dark brown pelletal mud

FB7: sand, pale yellow, pelletal
- mottled, banded in X – ray radiographs as indicated by rows of vertical root hairs with carbonate linings.

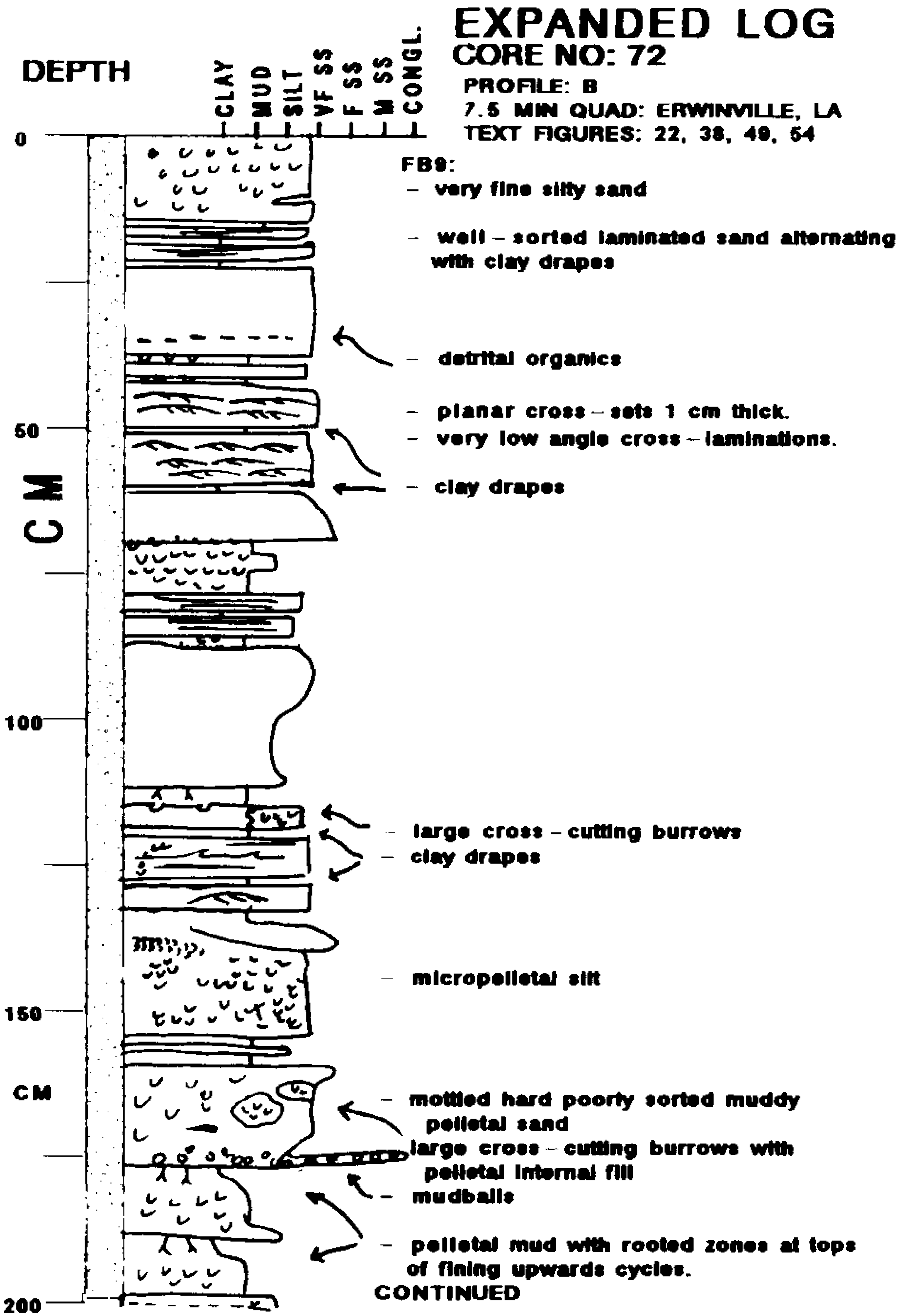
- very hard, yellowish mud/clayey silt structureless, poorly sorted

---

- multiple fining upward sequences about 10 cm thick. Silt fines up into mud. micropelletal fabric. granular Fe – oxides concentrated in finer layers.

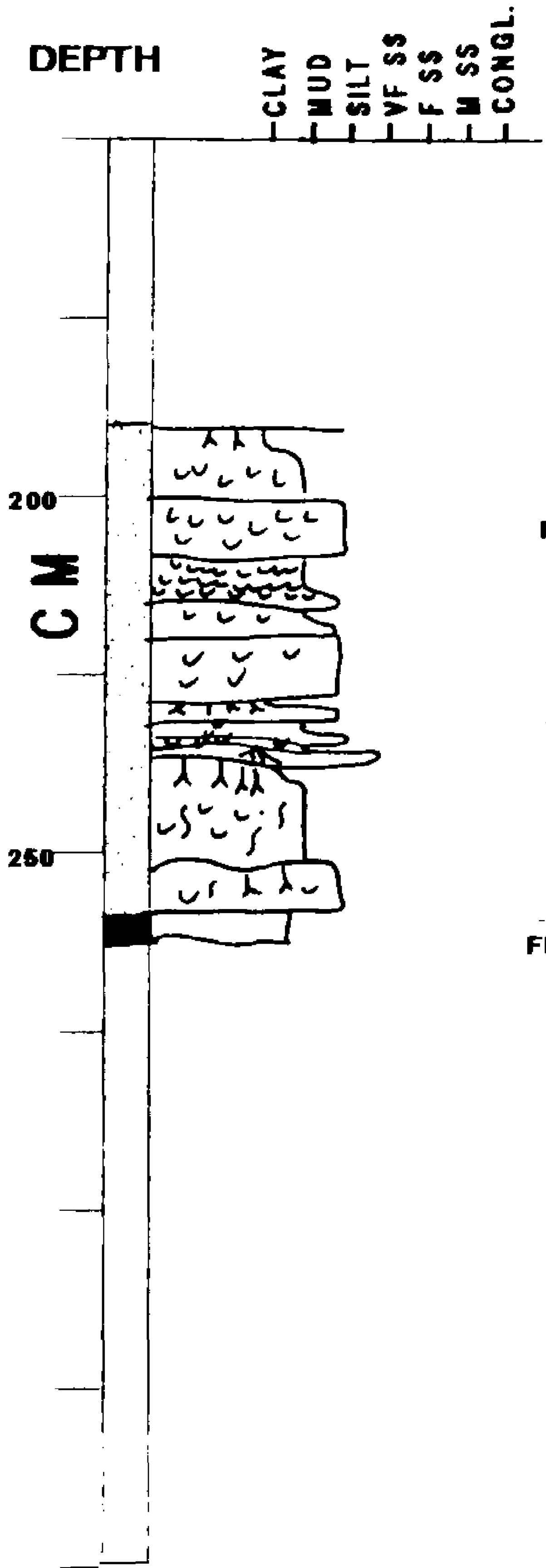
- poorly structured mud/clayey silt and very fine sand. Extremely poorly sorted.

- pelletal silt


EXPANDED LOG
CORE NO: 72
PROFILE: B
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 22, 38, 49, 54
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
50
C M
100
150
CM
200
FB9:
– very fine silty sand
– well – sorted laminated sand alternating with clay drapes
– detrital organics
– planar cross – sets 1 cm thick.
– very low angle cross – laminations.
– clay drapes
– large cross – cutting burrows
– clay drapes
– micropelletal silt
– mottled hard poorly sorted muddy pelletal sand
large cross – cutting burrows with pelletal internal fill
– mudballs
– pelletal mud with rooted zones at tops of fining upwards cycles.
CONTINUED

EXPANDED LOG
CORE NO: 72 CONTINUED

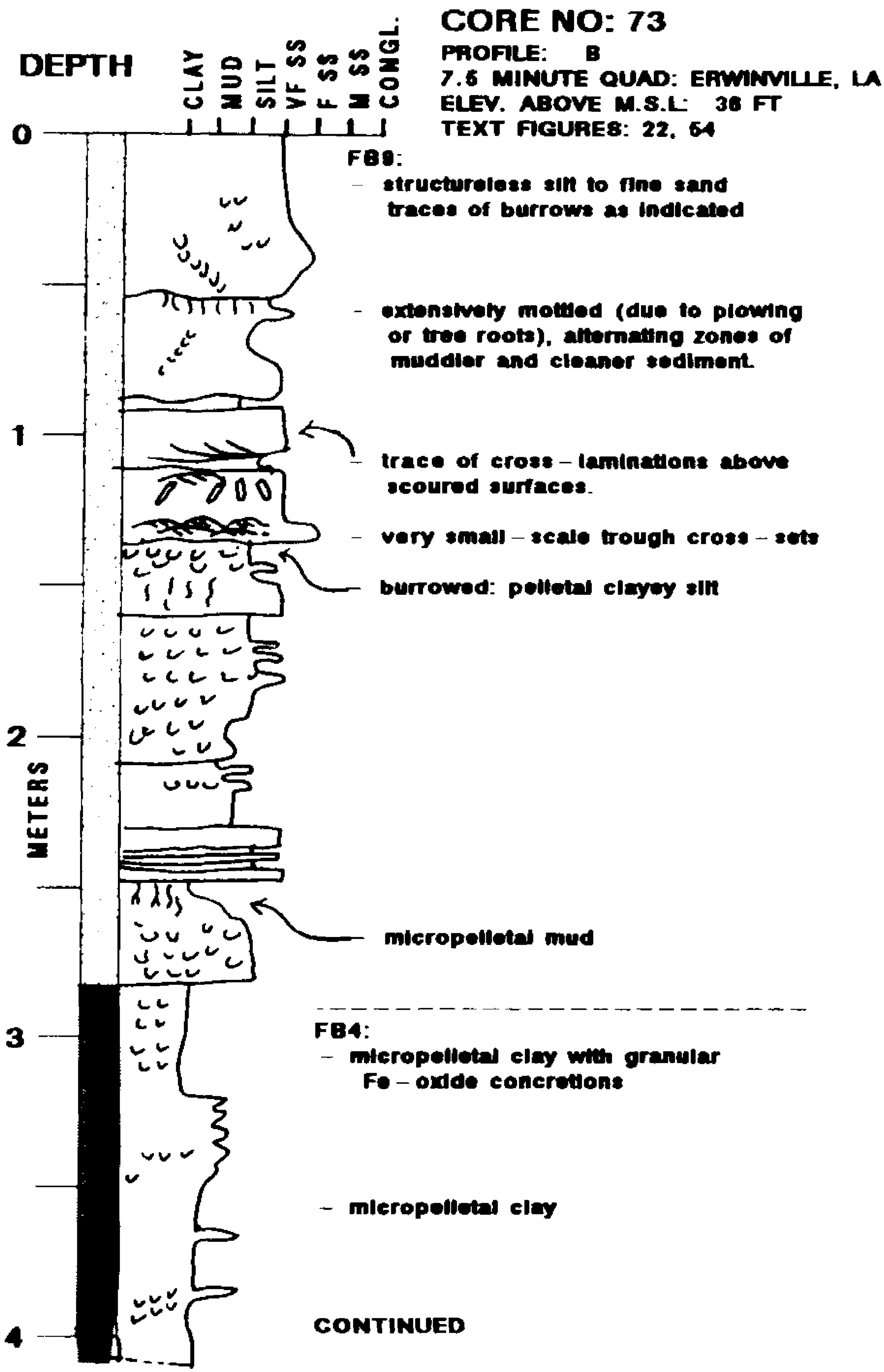
PROFILE: B
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 22, 38, 49, 54

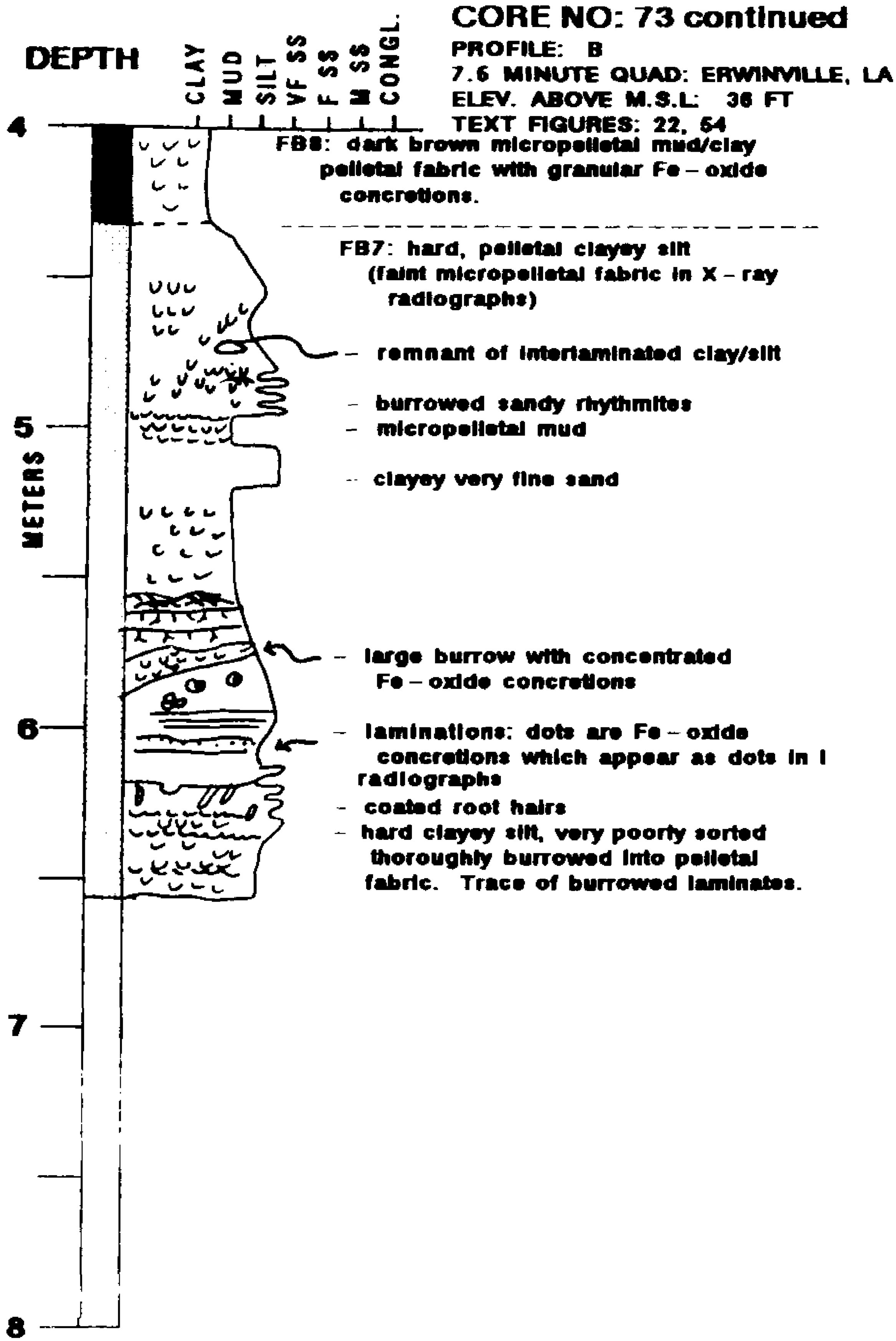


FB9 CONTINUED:
- **pelletal mud and silt with root hairs**

- **rhythmites, partially burrowed**

FB4: ROOTED MUD


CORE NO: 73
PROFILE: B
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 36 FT
TEXT FIGURES: 22, 54
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
1
2
3
4
METERS
FB9:
– structureless silt to fine sand traces of burrows as indicated
– extensively mottled (due to plowing or tree roots), alternating zones of muddier and cleaner sediment.
– trace of cross – laminations above scoured surfaces.
– very small – scale trough cross – sets
burrowed: pelletal clayey silt
micropelletal mud
FB4:
– micropelletal clay with granular Fe – oxide concretions
– micropelletal clay
CONTINUED


CORE NO: 73 continued
PROFILE: B
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 36 FT
TEXT FIGURES: 22, 54
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
METERS
4
5
6
7
8
FB8: dark brown micropelletal mud/clay pelletal fabric with granular Fe – oxide concretions.
FB7: hard, pelletal clayey silt (faint micropelletal fabric in X – ray radiographs)
remnant of interlaminated clay/silt
burrowed sandy rhythmites
micropelletal mud
clayey very fine sand
large burrow with concentrated Fe – oxide concretions
laminations: dots are Fe – oxide concretions which appear as dots in I radiographs
coated root hairs
hard clayey silt, very poorly sorted thoroughly burrowed into pelletal fabric. Trace of burrowed laminates.

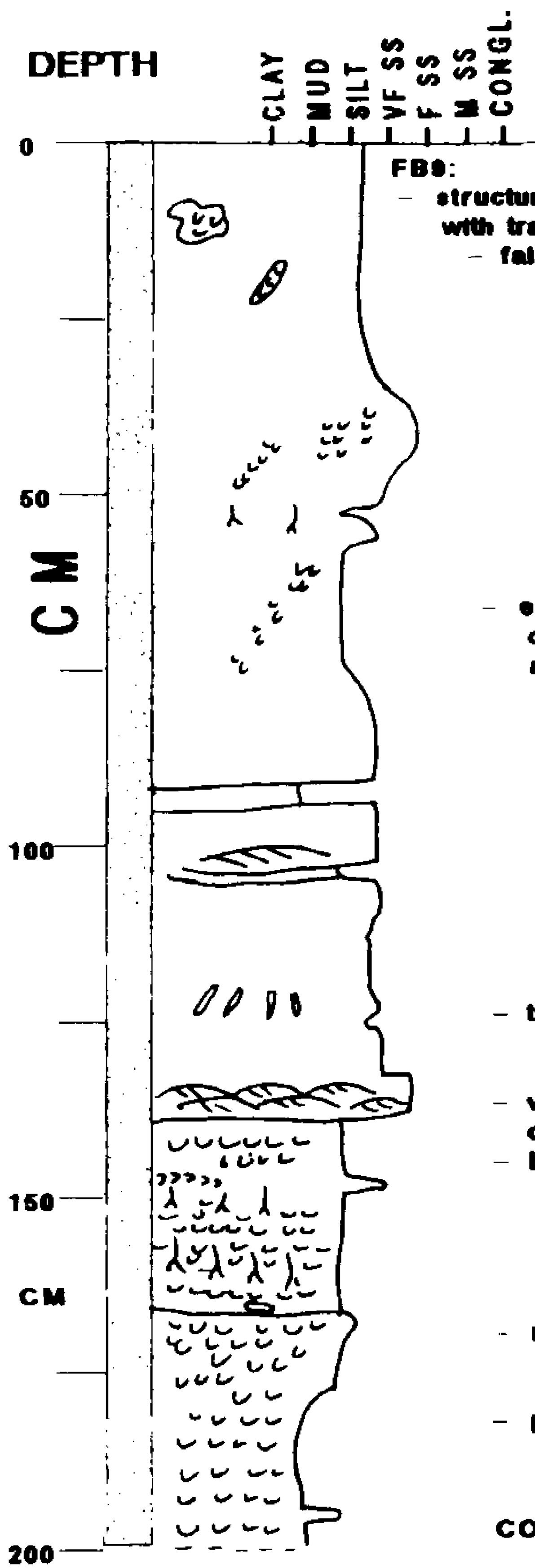
EXPANDED LOG

CORE NO: 73

PROFILE: B

7.5 MIN QUAD: ERWINVILLE, LA

TEXT FIGURES: 22, 54



FB9:

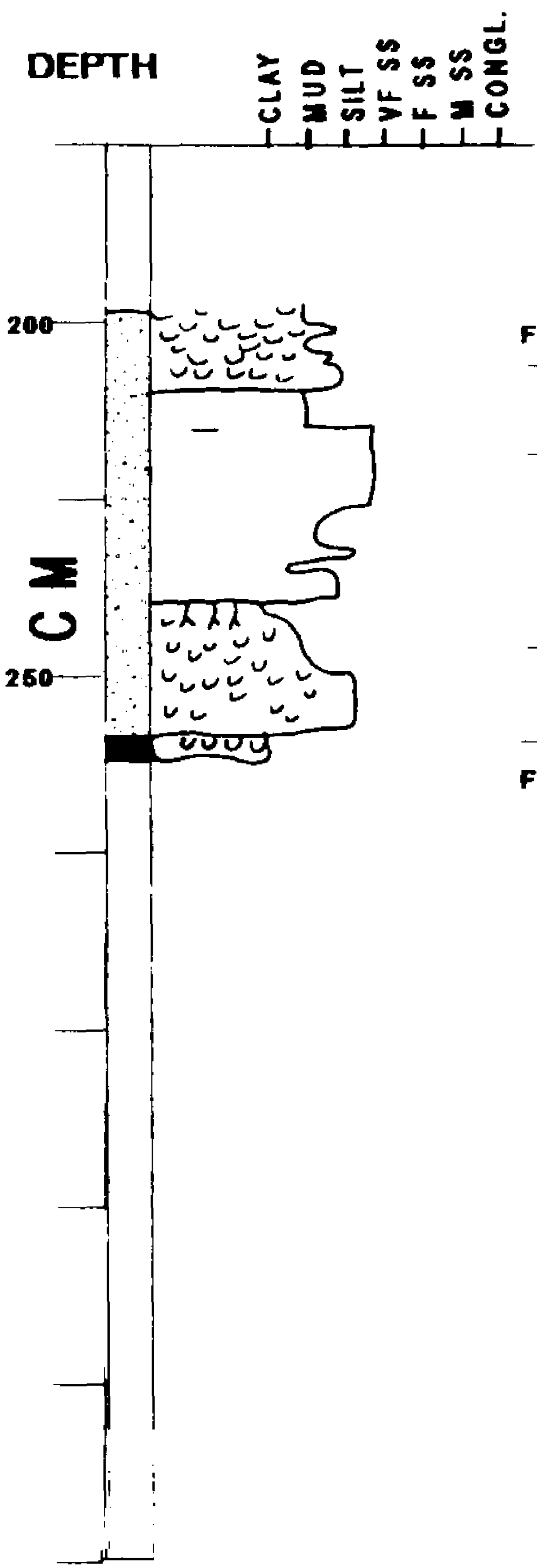
- structureless silt to fine sand with traces of burrows as indicated.
  - faintly banded
- extensive mottling superimposed on alternating zones of muddier and cleaner sediment.
- tiny coated root hairs
- very small – scale (cm) trough cross – sets.
- burrowed, clayey pelletal silt
- mudball
- pelletal mud and silt

CONTINUED

EXPANDED LOG

CORE NO: 73 CONTINUED

PROFILE: B
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 22, 54



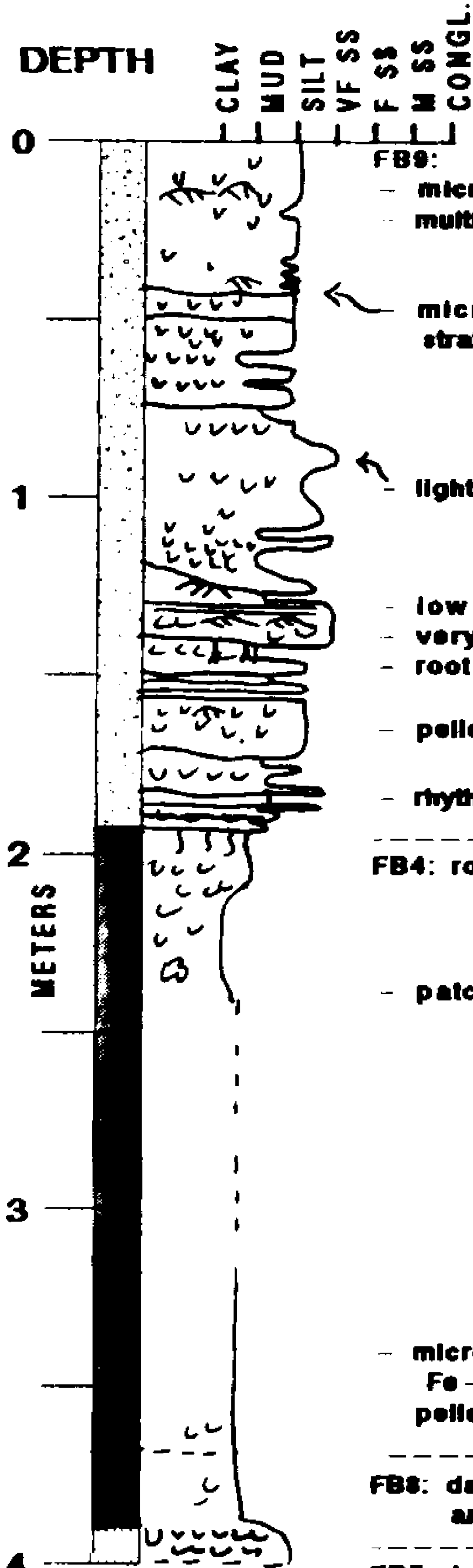
FB9 CONTINUED

- micropelletal mud and silt
- relatively structureless banded muddy sand
- micropelletal hard mud, rooted zone at top.

FB4: micropelletal clay

CORE NO: 74

PROFILE: B
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 34.5 FT
TEXT FIGURES: 22, 40, 64



FB9:
- micropelletal silt
- multiple clay drapes over small ripple forms.
- micropelletal silt and remnants of rhythmic stratification.
- lightly mottled very fine sand, micropelletal
- low angle cross – laminations
- very small – scale trough cross – sets.
- root hairs in pelletal mud
- pelletal silt
- rhythmites, partially burrowed.

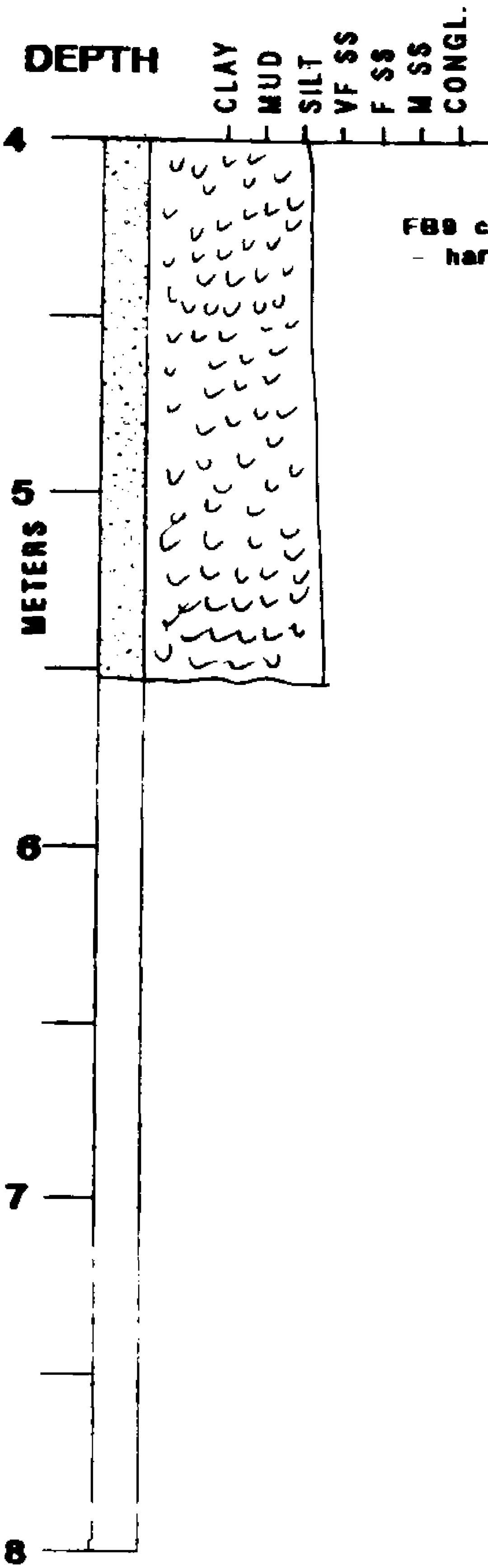
FB4: rooted micropelletal clay

- patchy mottles

- micropelletal clay with granular Fe – oxide concretions in pellet matrix

FB8: dark brown micropelletal clay and mud

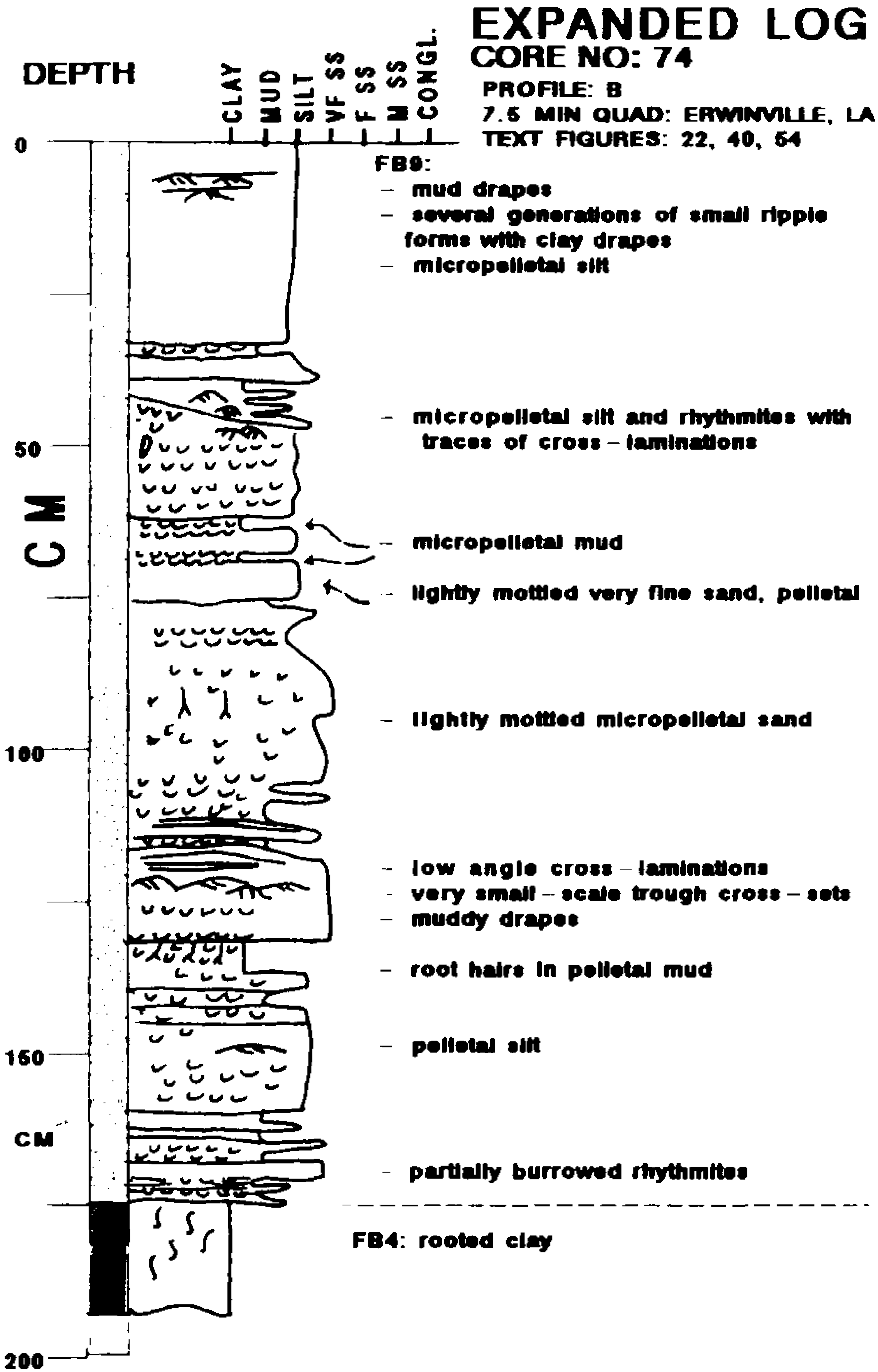
FB7: hard clayey silt, pelletal, CONTINUED



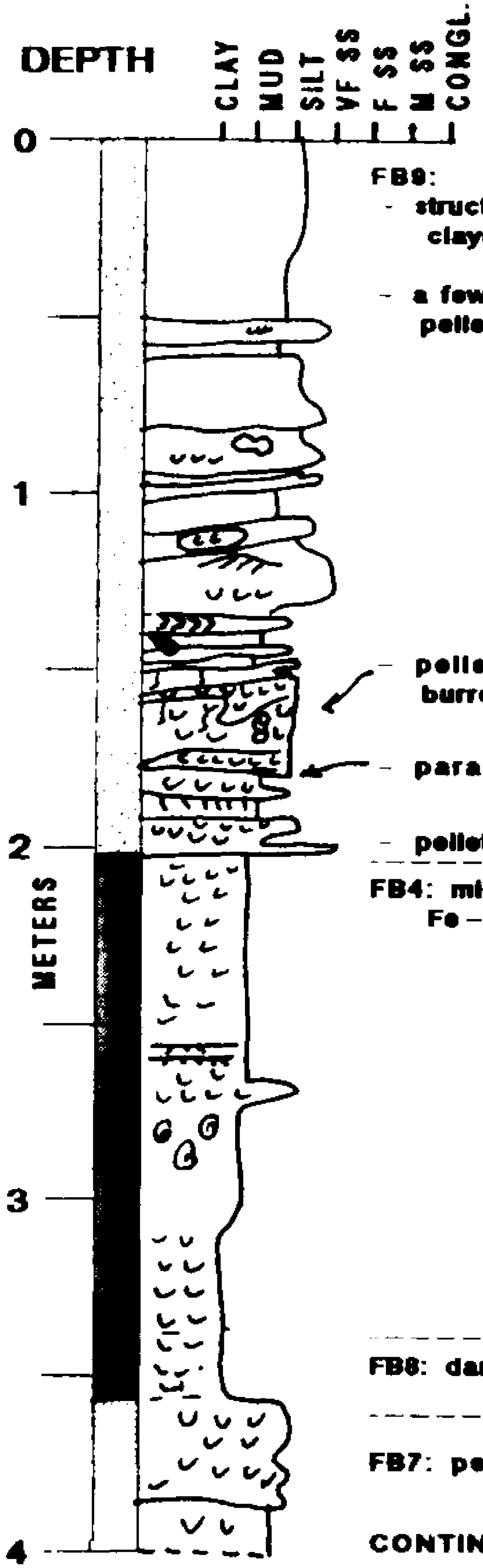
CORE NO: 74 CONTINUED

PROFILE: B
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 34.5
TEXT FIGURES: 22, 40, 54

FB8 continued.
- **hard, micropelletal clayey silt**


EXPANDED LOG
CORE NO: 74
PROFILE: B
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 22, 40, 54
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
50
CM
100
150
CM
200
FB9:
– mud drapes
– several generations of small ripple forms with clay drapes
– micropelletal silt
– micropelletal silt and rhythmites with traces of cross – laminations
– micropelletal mud
– lightly mottled very fine sand, pelletal
– lightly mottled micropelletal sand
– low angle cross – laminations
– very small – scale trough cross – sets
– muddy drapes
– root hairs in pelletal mud
– pelletal silt
– partially burrowed rhythmites
FB4: rooted clay

CORE NO: 75
PROFILE: 8
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 34 FT
TEXT FIGURES: 22, 37, 54



FB9:
- structureless to lightly burrowed silt and clayey silt.
- a few large cross – cutting burrows with pelletal internal fabric.
- pelletal silt with large cross – cutting burrows with internal pelletal fabric.
- parallel laminations
- pelletal silt

FB4: micropelletal clay with granular Fe – oxide concretions

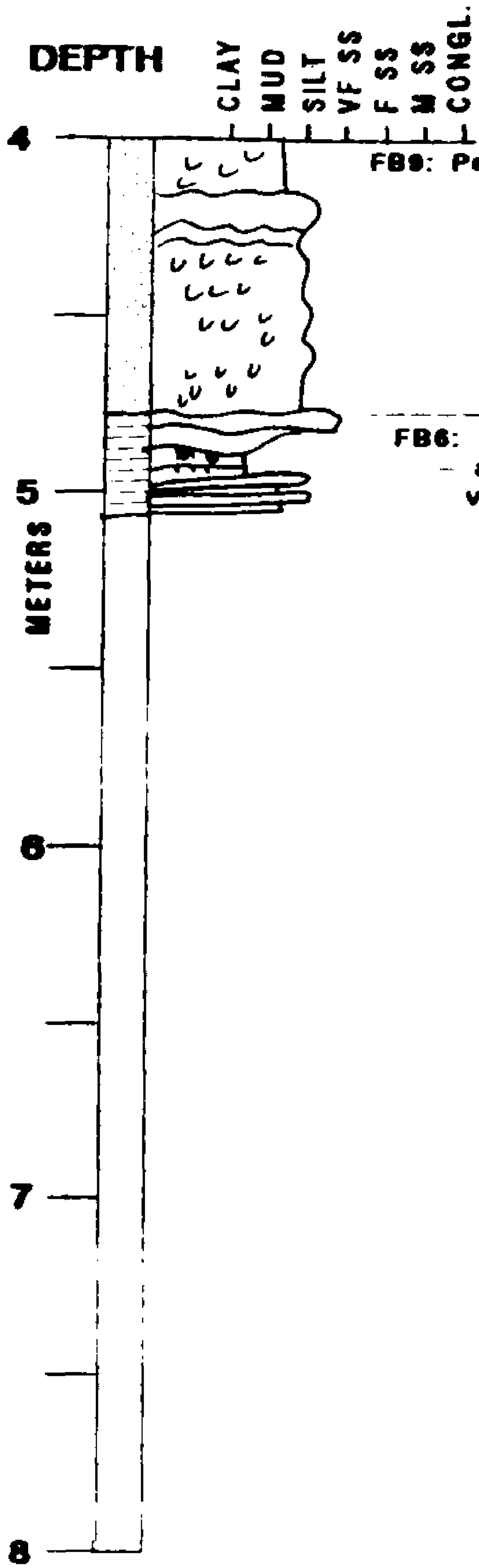
FB8: dark brown micropelletal clay

FB7: pelletal silt

CONTINUED

CORE NO: 75 CONTINUED

PROFILE: B
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 34 FT
TEXT FIGURES: 22, 37, 54



FB9: Pelletal silt

FB6:
- alternating layers of silt and clayey silt, very hard, looks laminated.

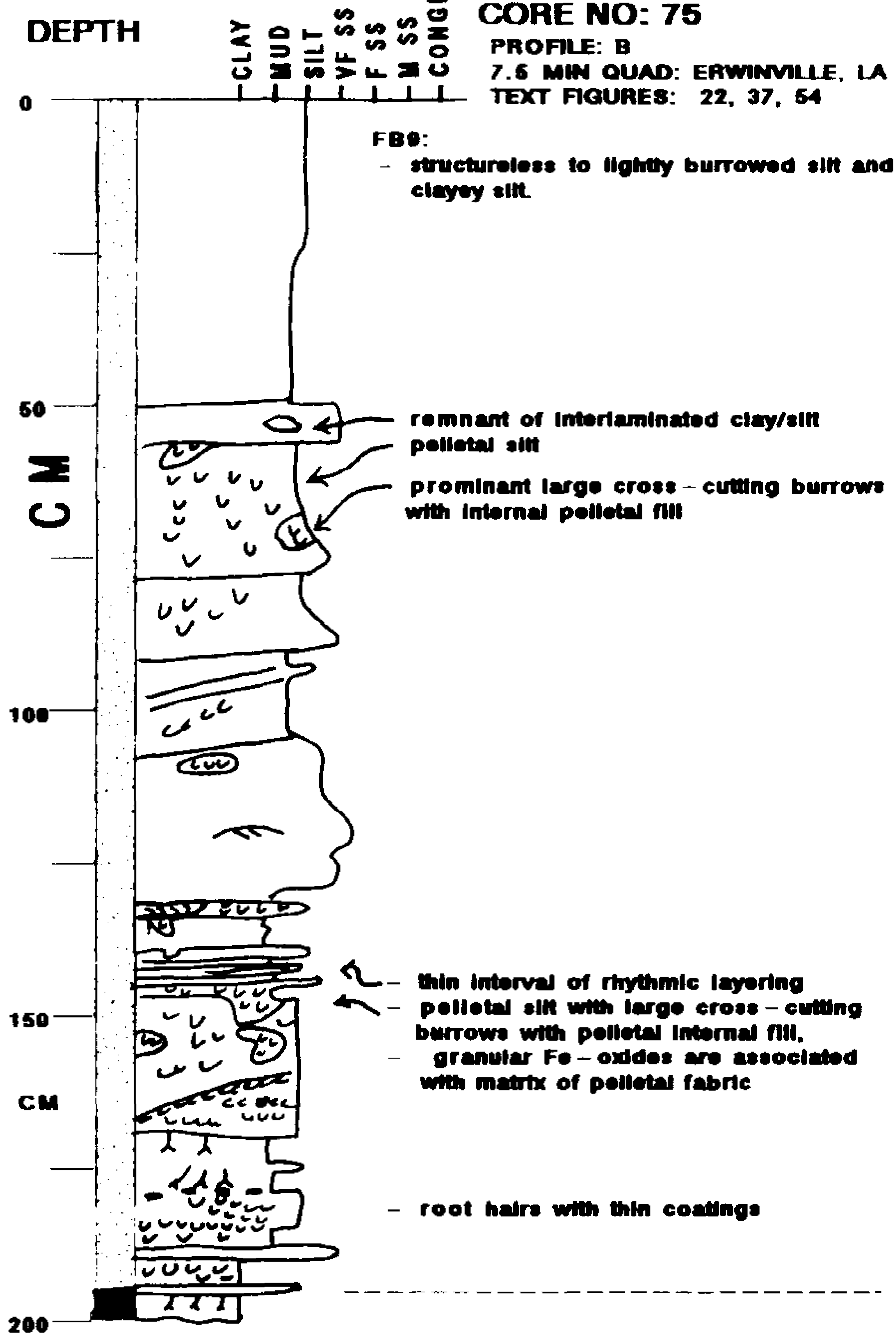
EXPANDED LOG

CORE NO: 75

PROFILE: B

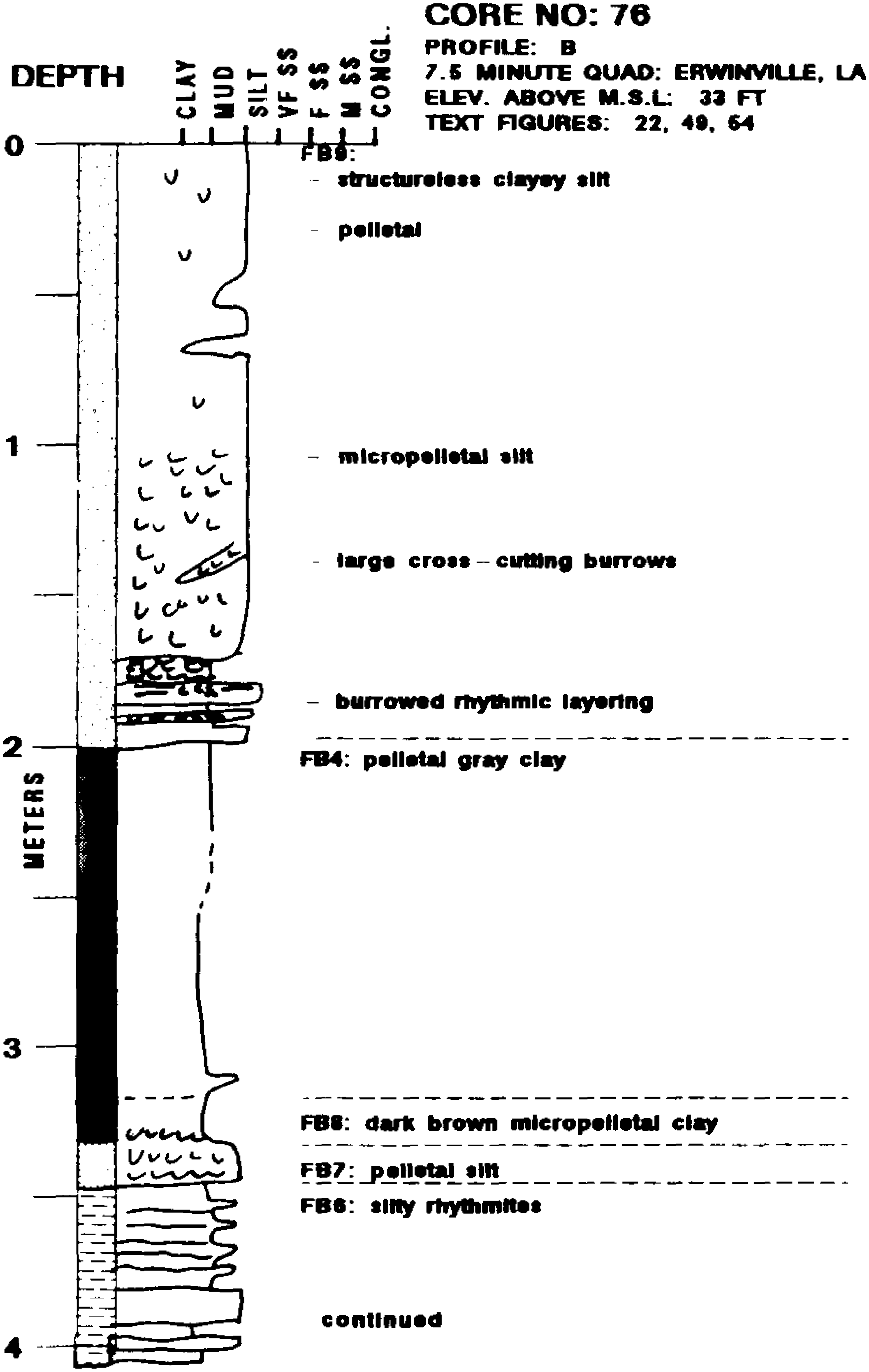
7.5 MIN QUAD: ERWINVILLE, LA

TEXT FIGURES: 22, 37, 54



CORE NO: 76

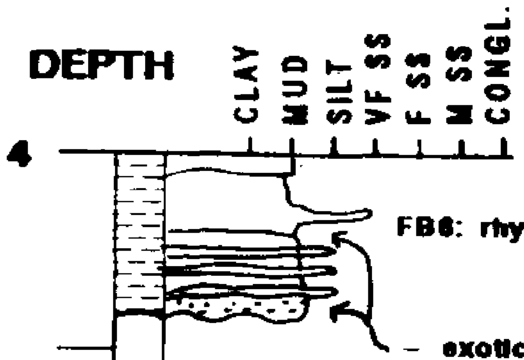
PROFILE: B
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 33 FT
TEXT FIGURES: 22, 49, 64



continued

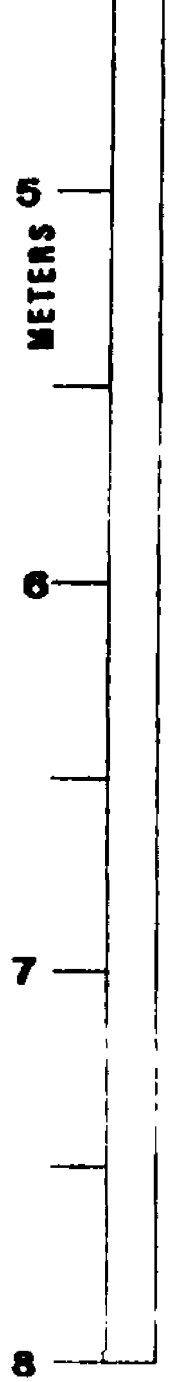
CORE NO: 76 continued

PROFILE: B
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 33 FT
TEXT FIGURES: 22, 49. 54

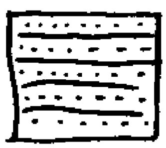


FB6: rhythmically layered

– exotic fabric (see below)



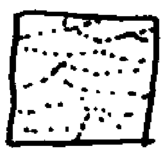
FB6 consists mostly of hard clayey silt.
It has traces of thin laminations of clay.
Clay laminations are about 1 MM thick and are slightly convoluted. Also present are Fe – oxides with a dot – like occurrence :



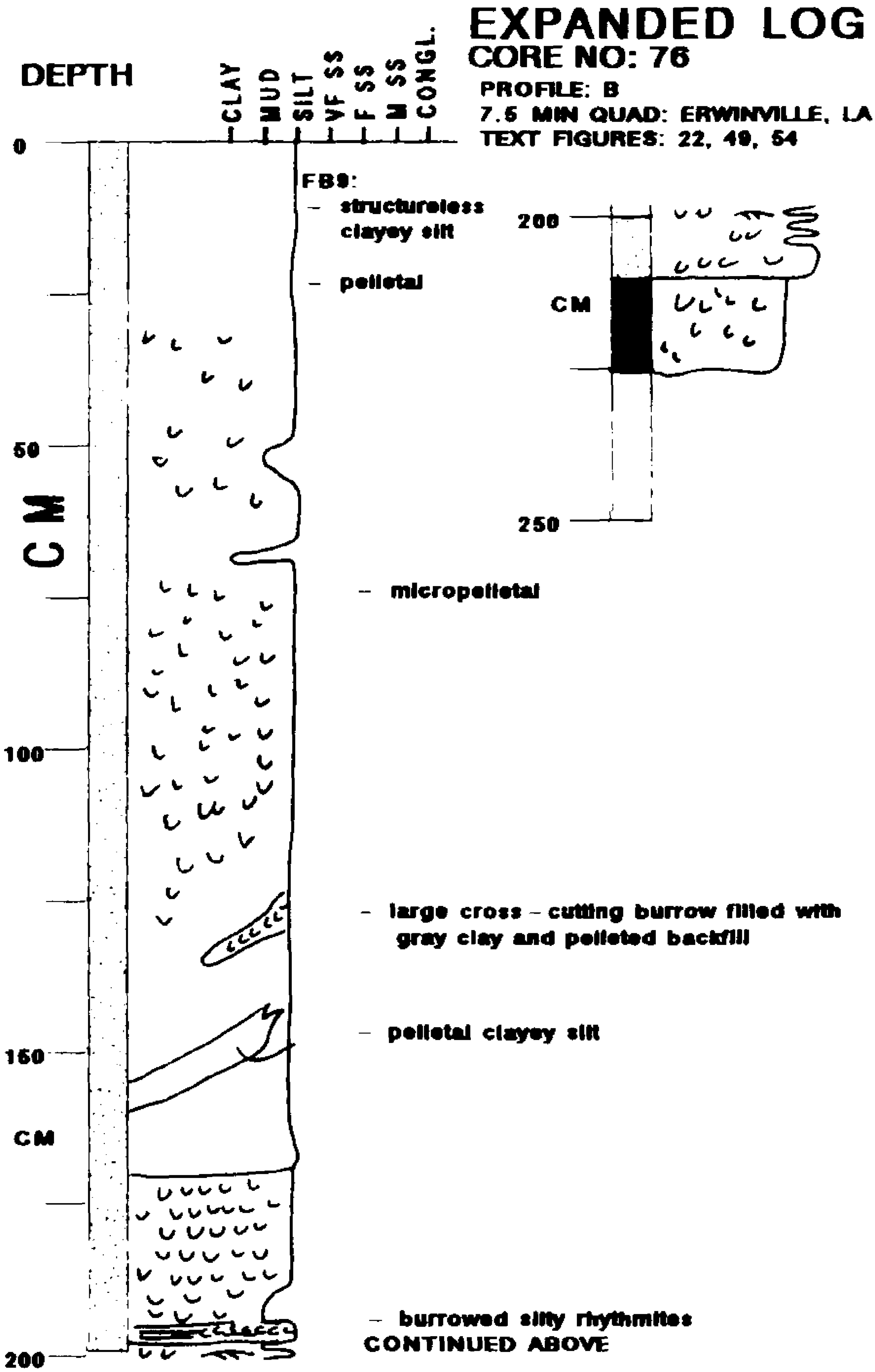
dot – like Fe – oxides

Dot – like Fe – oxide concretions were probably precipitated on tiny root hairs serving as nuclei.

Over compaction of cores causes this lithology to compact into a chickenwire like texture:

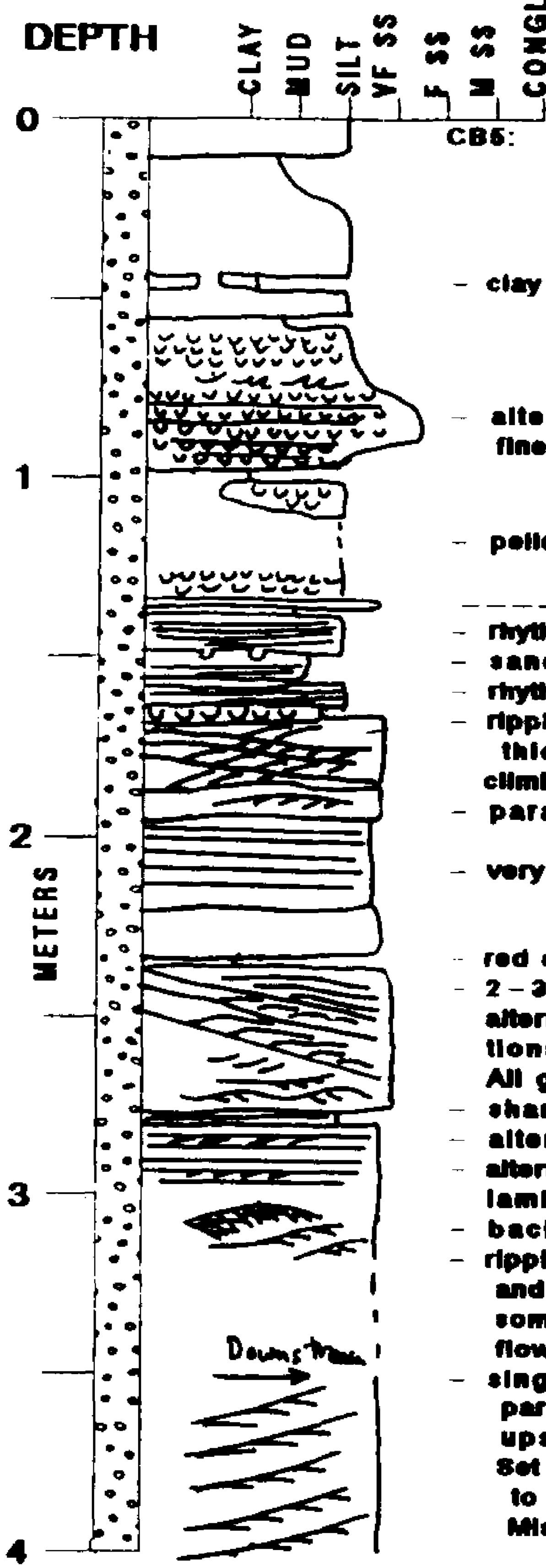


Fe – oxides outline chickenwire – like texture


EXPANDED LOG
CORE NO: 76
PROFILE: B
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 22, 49, 54
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
50
CM
100
150
CM
200
FB9:
– structureless clayey silt
– pelletal
– micropelletal
– large cross – cutting burrow filled with gray clay and pelleted backfill
– pelletal clayey silt
– burrowed silty rhythmites
CONTINUED ABOVE
200
CM
250

CORE NO: 77

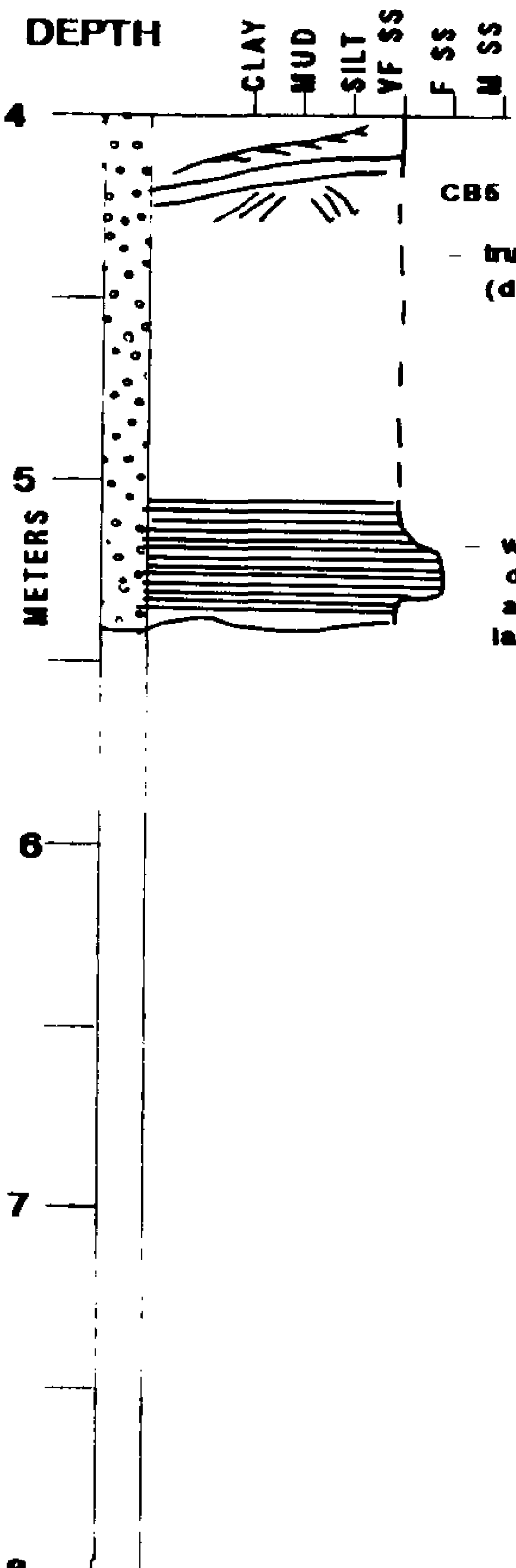
PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 36 FT
TEXT FIGURES: 22, 23, 22



- clay drape
- alternating laminations of pelletal mud and fine well – sorted sand
- pelletal silt

- rhythmically layered mud and laminated silt
- sand – filled burrows extend down from contact
- rhythmically layered mud and laminated silt
- ripple drift: Type A/B transition, sets 2 – 3 cm thick, tangential contacts
  climb upstream relative to main stream flow.
- parallel laminations change up into ripple drift
- very fine laminated sand
- red clay drape
- 2 – 3 cm thick sets of ripple drift (Type A/B trans) alternate with 1 cm thick sets of parallel laminations (sinusoidal ripples?).
  All gradational contacts.
- sharp scoured contact
- alternating silt and very fine sand laminations
- alternating layers of very low angle cross – laminations and parallel laminations
- backflow ripple bedding
- ripple drift sets 1 to 5 cm thick, mostly Type B and Type A/B transition
  some scour and fill surfaces
  flow is downstream parallel to the mainstream.
- single continuous set of ripple drift;
  parallel laminations change gradationally upsection into sinusoidal, then Type B.
  Set climbs downsream approximately parallel to downstream on the main channel of the Mississippi River. CONTINUED

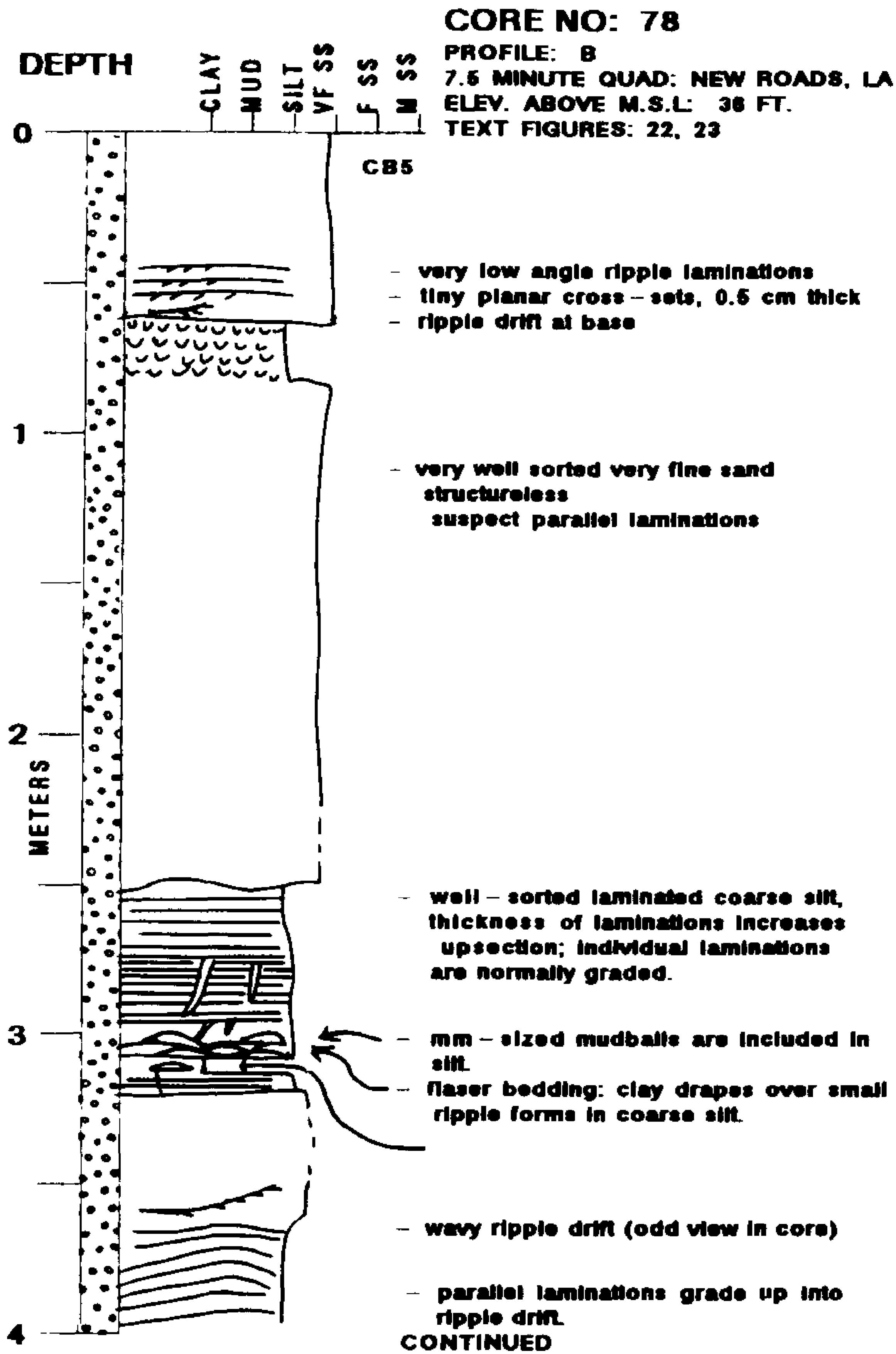
CORE NO: 77 CONTINUED
PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 36 FT
TEXT FIGURES: 22, 23, 27



CB5 CONTINUED

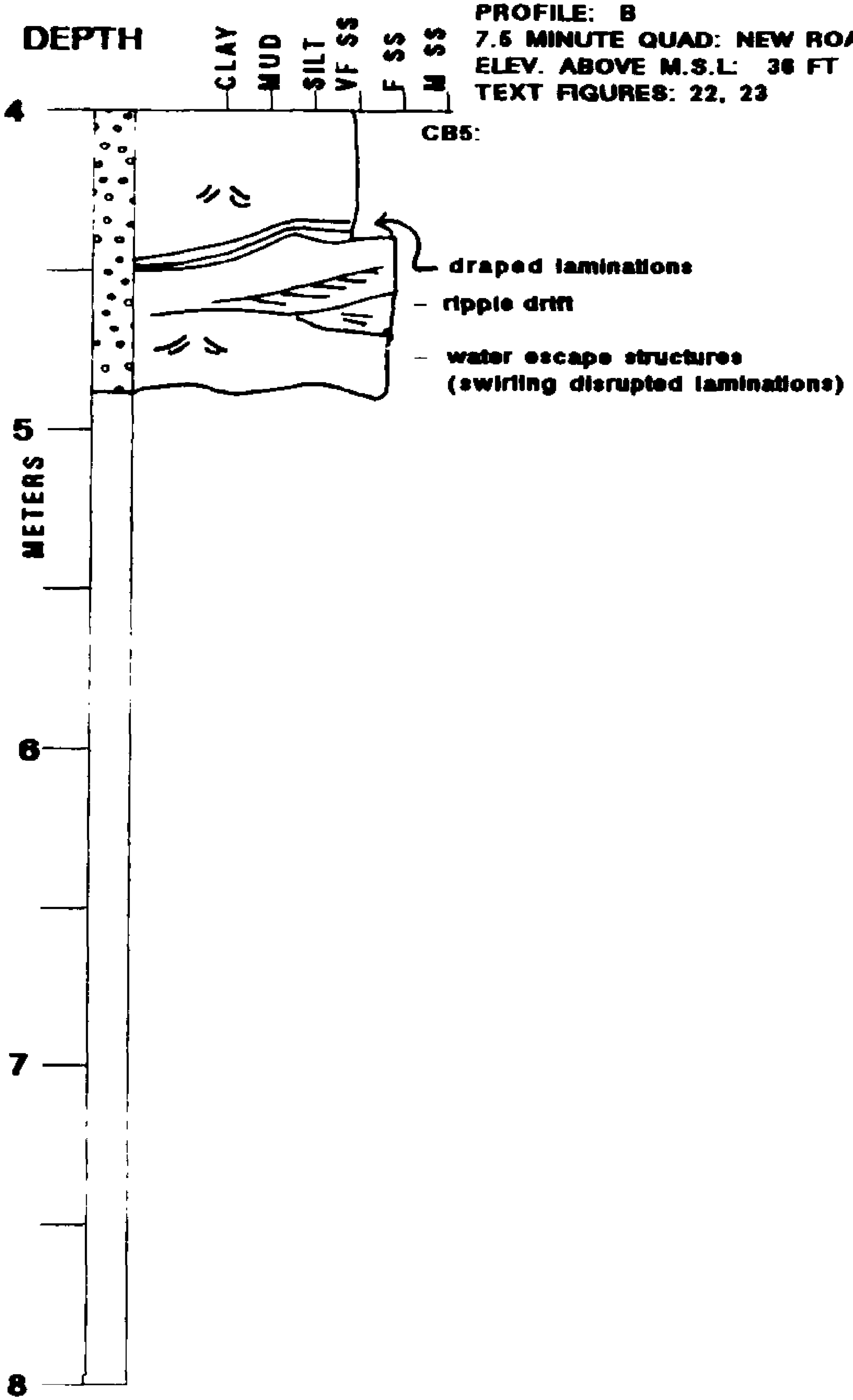
- **truncated water escape structures (disrupted laminations)**

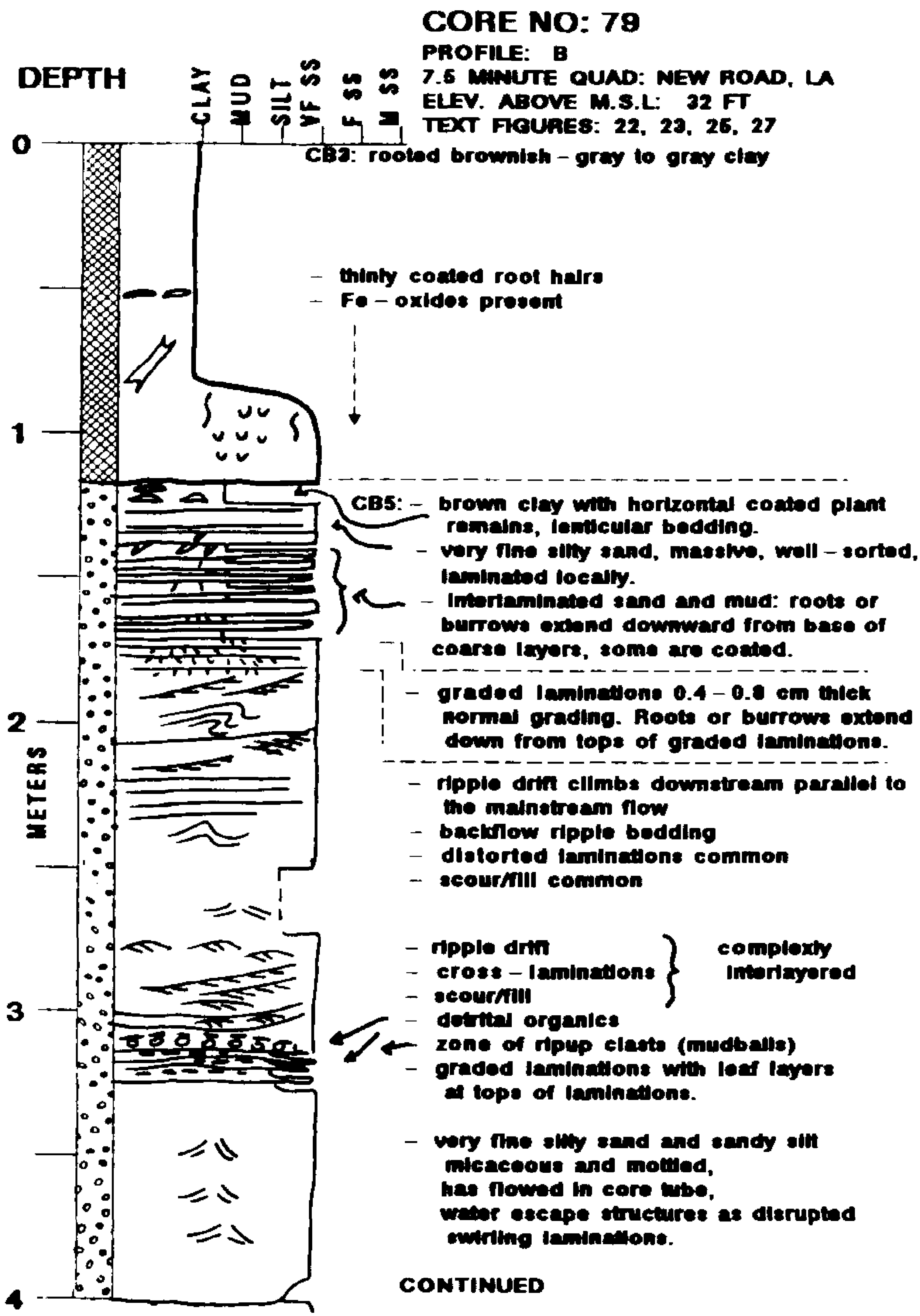
- **well – sorted laminated sand dark (organic – rich?) laminations alternated with light (quartz – rich) laminations.**


CORE NO: 78
PROFILE: B
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 38 FT.
TEXT FIGURES: 22, 23
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
0
1
2
3
4
METERS
CB5
- very low angle ripple laminations
- tiny planar cross-sets, 0.5 cm thick
- ripple drift at base
- very well sorted very fine sand
structureless
suspect parallel laminations
- well-sorted laminated coarse silt,
thickness of laminations increases
upsection; individual laminations
are normally graded.
- mm-sized mudballs are included in
silt.
- flaser bedding: clay drapes over small
ripple forms in coarse silt.
- wavy ripple drift (odd view in core)
- parallel laminations grade up into
ripple drift.
CONTINUED

CORE NO: 78 CONTINUED

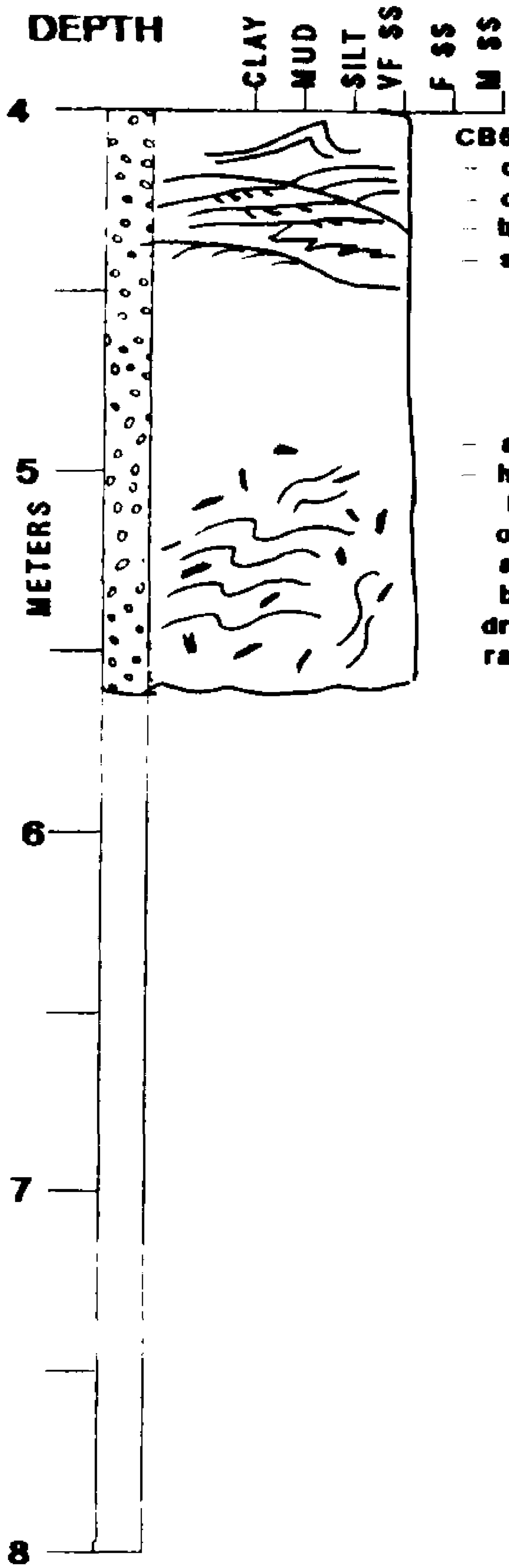
PROFILE: B
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 36 FT
TEXT FIGURES: 22, 23




CORE NO: 79
PROFILE: B
7.5 MINUTE QUAD: NEW ROAD, LA
ELEV. ABOVE M.S.L: 32 FT
TEXT FIGURES: 22, 23, 25, 27
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
0
1
2
3
4
METERS
CB3: rooted brownish – gray to gray clay
– thinly coated root hairs
– Fe – oxides present
CB5: – brown clay with horizontal coated plant remains, lenticular bedding.
– very fine silty sand, massive, well – sorted, laminated locally.
– interlaminated sand and mud: roots or burrows extend downward from base of coarse layers, some are coated.
– graded laminations 0.4 – 0.8 cm thick normal grading. Roots or burrows extend down from tops of graded laminations.
– ripple drift climbs downstream parallel to the mainstream flow
– backflow ripple bedding
– distorted laminations common
– scour/fill common
– ripple drift
– cross – laminations
– scour/fill
complexly interlayered
– detrital organics
– zone of ripup clasts (mudballs)
– graded laminations with leaf layers at tops of laminations.
– very fine silty sand and sandy silt micaceous and mottled, has flowed in core tube, water escape structures as disrupted swirling laminations.
CONTINUED

CORE NO: 79 CONTINUED

PROFILE: B
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 32 FT
TEXT FIGURES: 22, 23, 25, 27



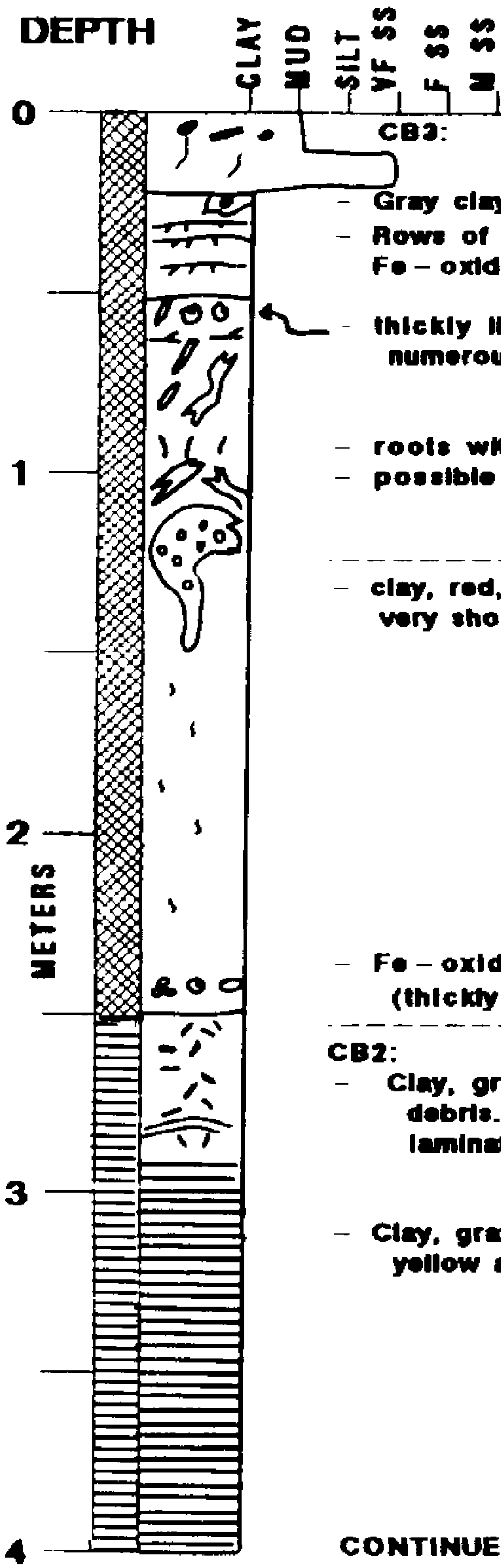
CB5 CONTINUED

- convoluted laminations
- detrital organics associated with ripples
- traces of ripple drift and cross – strata
- scour/fill surfaces

- abundant large micas and leaf debris
- highly disturbed, however traces of laminations are present that were probably originally horizontal. Also leaf fragments and detrital organics which also would have been originally horizontal or deposited as drapes. These organics are mixed in randomly with swirling laminations.

CORE NO: 80

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 32 FT
TEXT FIGURES: 22, 23, 25



CB3:

- Gray clay with Fe – oxide coatings on roots;
- Rows of upwardly terminating root hairs with Fe – oxide coatings (visible in radiographs)
- thickly lined burrows and snail shells numerous branching rootlets or branches
- roots with Fe – oxide coatings
- possible clay ripup clasts

- clay, red, quite pure, contains only a few very short root hairs with thin linings.
- Fe – oxide nodules along horizons (thickly coated plant remains)

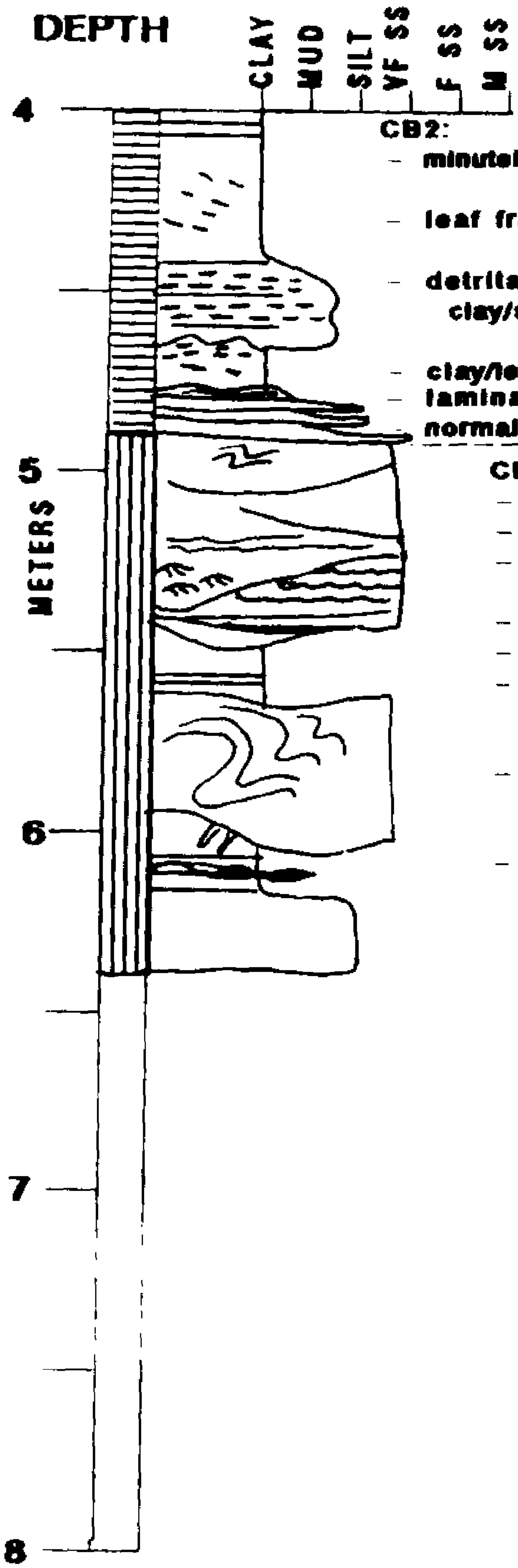
CB2:

- Clay, gray with detrital, disseminated plant debris. laminations present but disrupted
- Clay, gray, minutely laminated, yellow and gray laminations locally

CONTINUED

CORE NO: 80 continued

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 32 FT
TEXT FIGURES: 22, 23, 25

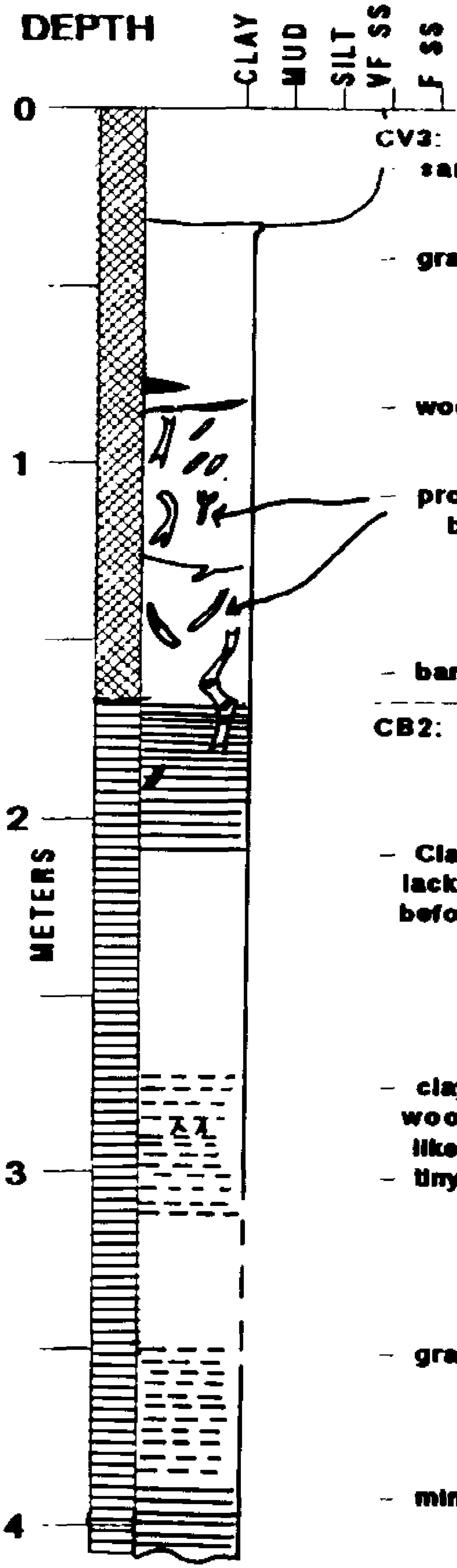


CB2:
- minutely laminated gray clay
- leaf fragments, inclined due to coring
- detrital organic laminations in laminated clay/silt
- clay/leaf laminates
- laminations
- normally graded layers: basal sand 1 mm thick

CB1:
- convoluted laminations
- traces of ripple drift
- scour and fill surfaces
- crenulated laminations
- detrital organics throughout sand
- parallel laminated clay
- convoluted laminations
- roots or burrows extend down from upper contact of clay lenticular bedding

CORE NO: 81

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 31 FT
TEXT FIGURES: 22, 23



CV3:

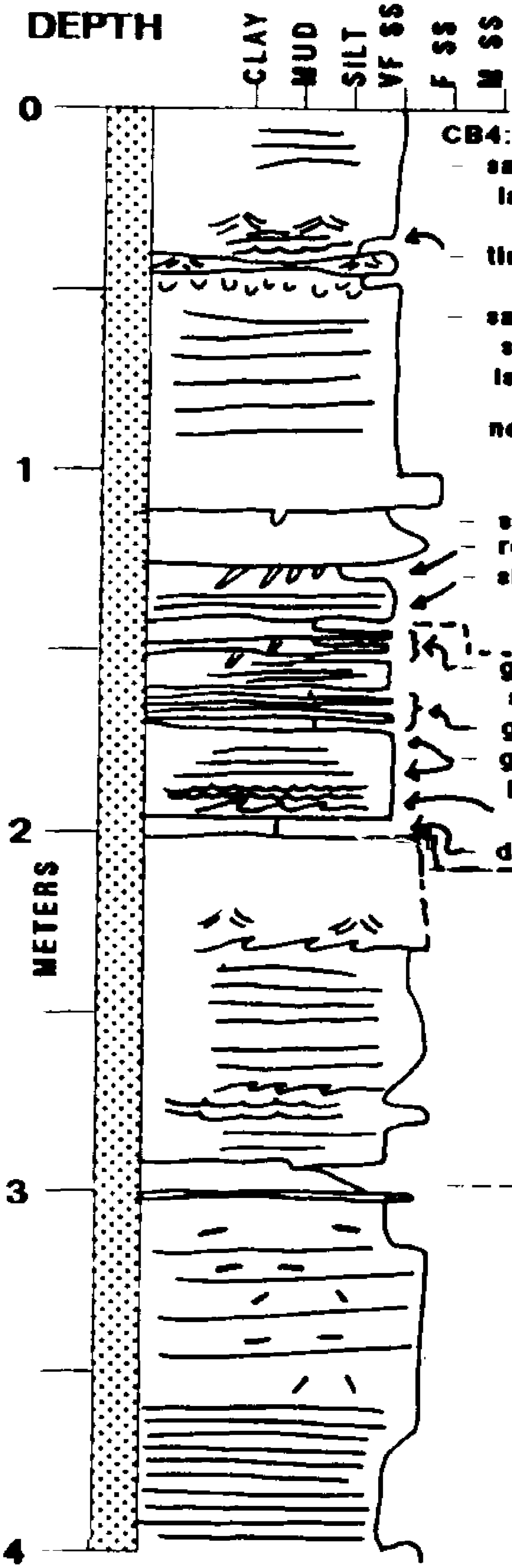
- sandy slump
- gray clay with orange mottling
- wood or roots
- prominant coated root hairs up to 10 cm long branches.
- banded red and gray clay

CB2:

- Clay, twisted in core tube, very fine and pure, lacks roots, probably was banded or laminated before it was disrupted.
- clay with detrital organics including small wood chips and abundant leaf fragments shaped like flakes. Leaf debris is sub - parallel.
- tiny root burrows or nematode burrows
- gray clay with leaf fragments
- minutely laminated gray and yellow clay

CORE NO: 82

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 35.5 FT
TEXT FIGURES: 22, 23, 27



CB4:

- sand, very fine, micaceous with disrupted laminations
- tiny crenulated laminations
- sand, very fine silty, with graded laminations: sand/clay depositional couplets: each couplet is 0.8 cm thick and is normally graded.

not to scale graded

- silty, fine micaceous sand
- root burrows coated with Fe – oxide
- silty very fine micaceous sand with normally graded laminations (sand fines up into muddy sand.
- graded layers: sand seam fines up into mud seam is only 1 or 2 grains thick
- graded: sand seam grades up into mud
- graded laminations (very fine sand fines up into silt and then clay over vertical thickness of 1 cm. Crenulated laminations at base.
- dark gray clay drape fining

- sand, dark gray, micaceous, laminated disrupted locally.

- flame structures
- crenulated

- very muddy sand and silt, organic – rich
- sand, very muddy, very fine

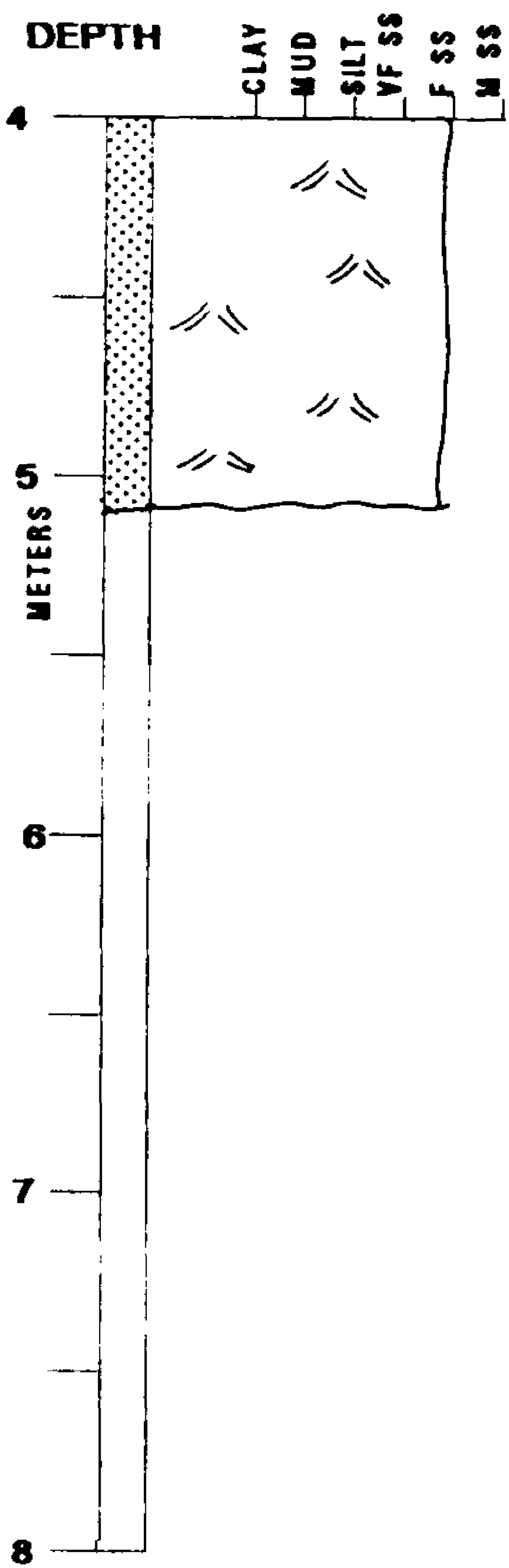
- sand, miceous, silty to muddy, GRADED water escape has disrupted laminations throughout. Banded with thin couplets of deposition :

0 – 2 cm thick

detrital organics at base of couplet which fines upward from sand into mud couplet is normally graded. CONTINUED

CORE NO: 82 continued

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 35.5 FT
TEXT FIGURES: 22, 23, 27

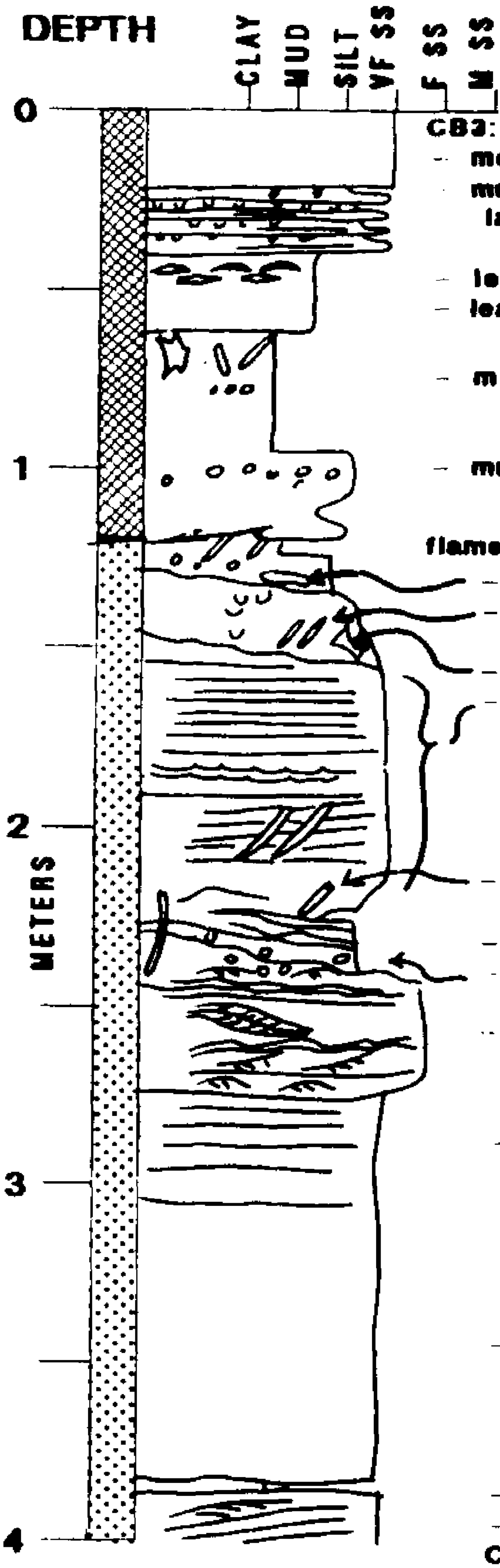


CB4 CONTINUED

- muddy to silty, 'dirty', micaceous sand dark gray with water escape disrupting strata (causes swirling laminations)

CORE NO: 83

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 33.5 FT
TEXT FIGURES: 22, 23, 27



CB3:
- mottled mud and very fine silty sand, micaceous
- multiple fining upward cycles that have a basal laminated sand that fines upward into clayey silt cycles about 4 cm thick
- lenticular bedding
- leaf fronds
- mudballs
- mudballs in very fine silty sand

CB3

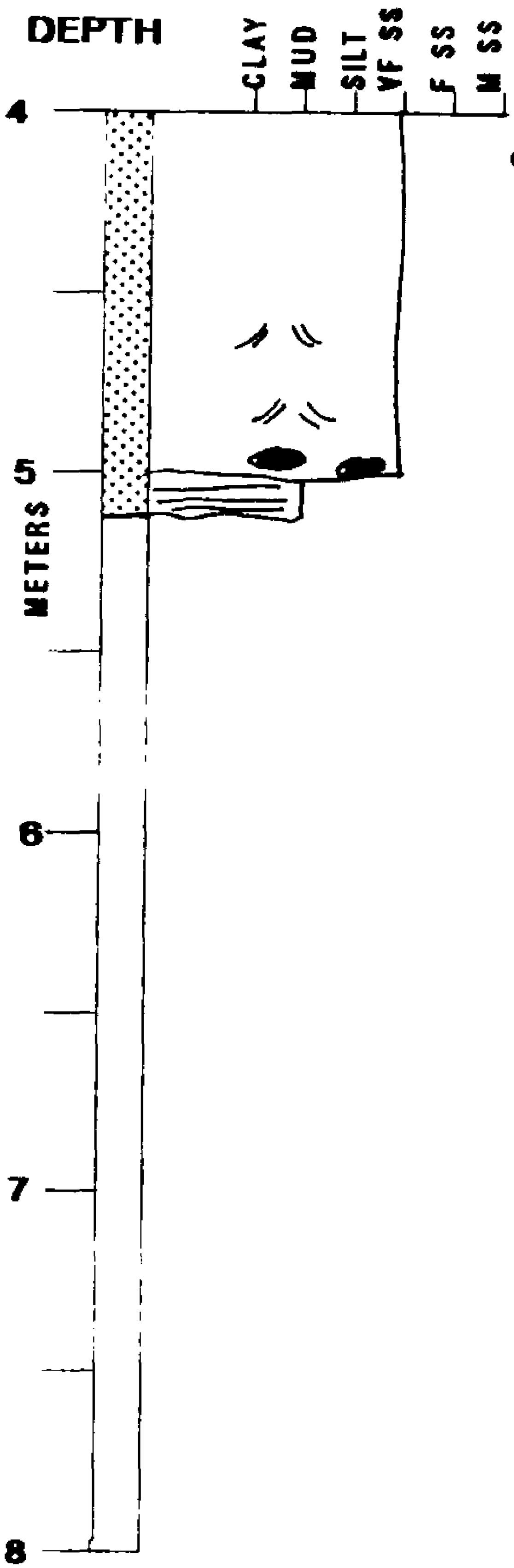
flame structures

- pink clay pods (mudballs?) CB4
- Fe – oxide linings on root hairs in silty to muddy very fine sand
- root burrow full of pink clay
- SAND, very fine, micaceous with graded layers 0.5 to 6.0 cm thick: basal white sand seam is 1/2 to 1/10th as thick as whole graded layer. Sand seam fines up into silty very fine sand or silt.
- roots with thick Fe – oxide coatings
- silt with wavy laminations
- mudballs
- complex with current structures: ripple drift, ripple laminations, back flow ripples, crenulated laminations.
- dark gary muddy sand with thick, mud – rich laminations that alternate with cleaner layers. Laminations are graded normally.
- mostly structureless due to coring or slumping.
- clay drape
- ripples, scour and fill, parallel laminations

CONTINUED

CORE NO: 83 continued

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 33.6 FT
TEXT FIGURES: 22, 23, 27



CB4: very fine silty sand, with disseminated organics, and wood chips at base.

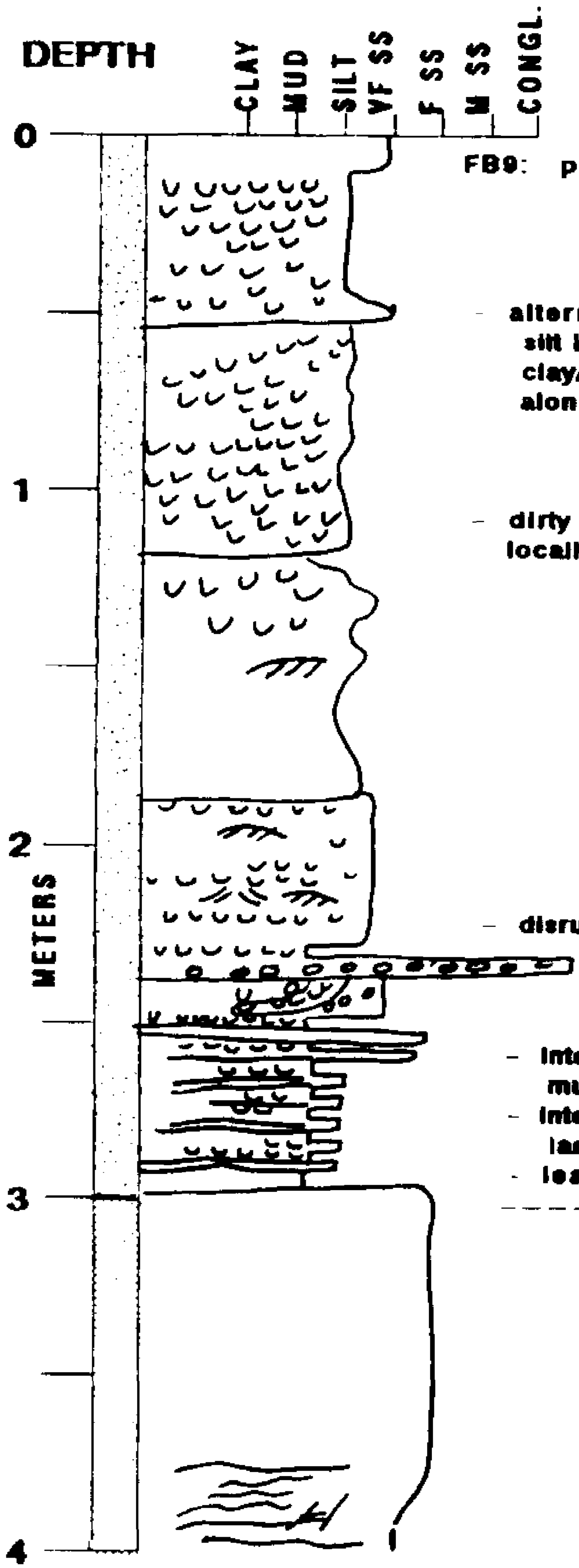
– flowage due to water escaping

– large branches

– parallel laminated clay

CORE NO: 84

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 34.5
TEXT FIGURES: 22, 23



FB9: pelletal silt predominates

- alternates between massive pelletal silt layers and burrowed (pelletal) clay/silt laminates (micropelletized along clay laminations).

- dirty and brownish, mud-rich locally

- disrupted laminae : water escape

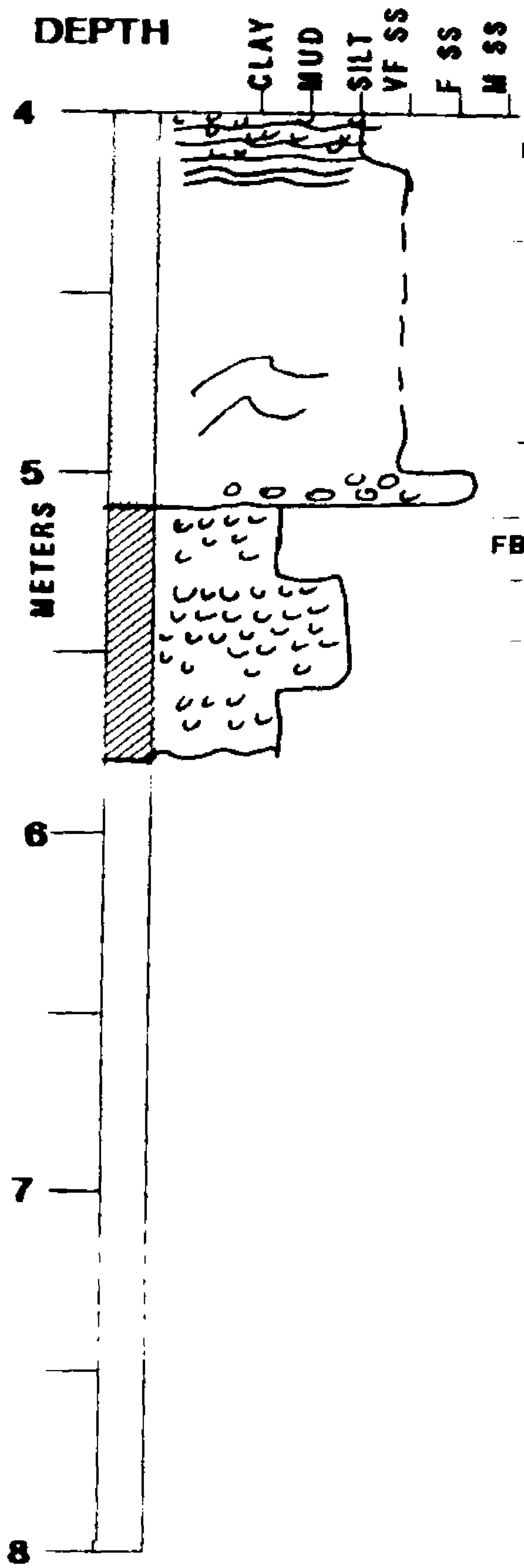
matrix in mudball bed: very fine sand
- mudballs and large burrows with pelletal internal fill.
- interlayered mud, fine sand, mud laminae burrowed.
- interlayered burrowed mud and laminated silt.
- leaves and detrital organics

FB7: well-sorted fine sand
- structureless due to flow
- water escape disruption due to coring.

- laminated fine sand and burrowed clayey silt.
- micro-faulted, swirling laminations. CONTINUED

CORE NO: 84 CONTINUED

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 34.5 FT
TEXT FIGURES: 22, 23



FB7 CONTINUED
- sand,mud, clay laminations, detrital organics
- wavey laminations

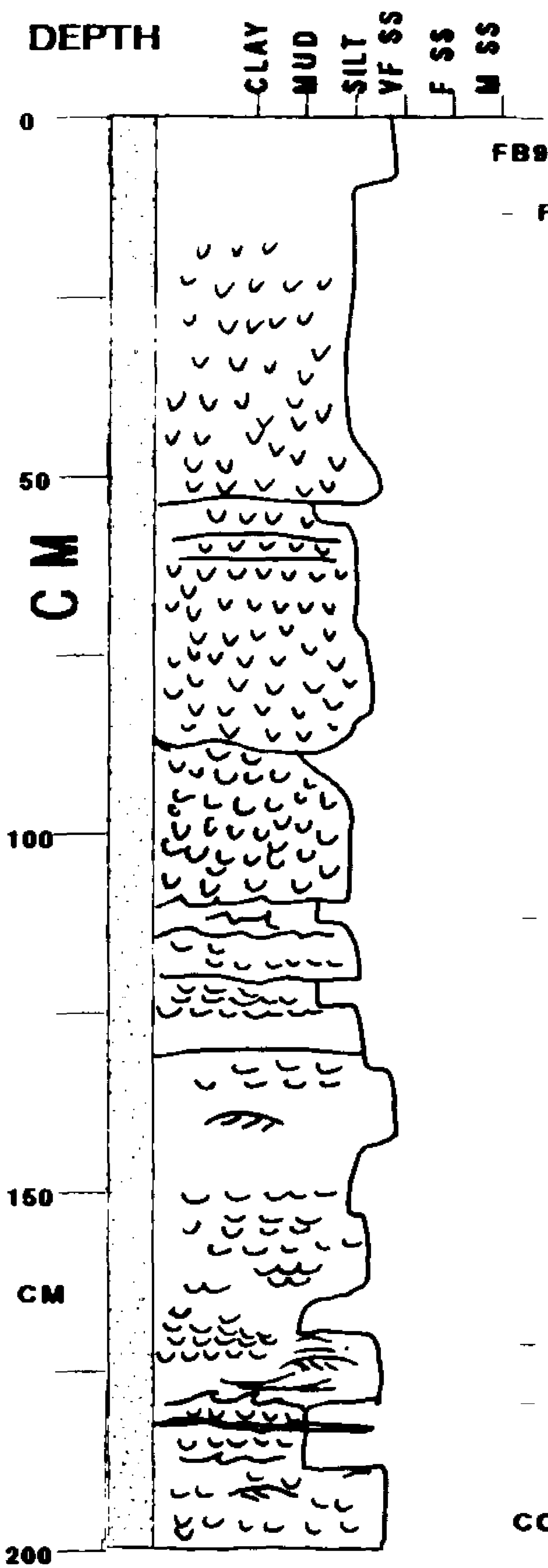
- brown clay blocks mudballs or slump?

FB5:
- pelletal clay
- pelletal clayey silt

EXPANDED LOG

CORE NO: 84

PROFILE: A
7.5 MIN QUAD: NEW ROADS, LA
TEXT FIGURES: 22, 23



FB9:

- Pelletal silt predominates

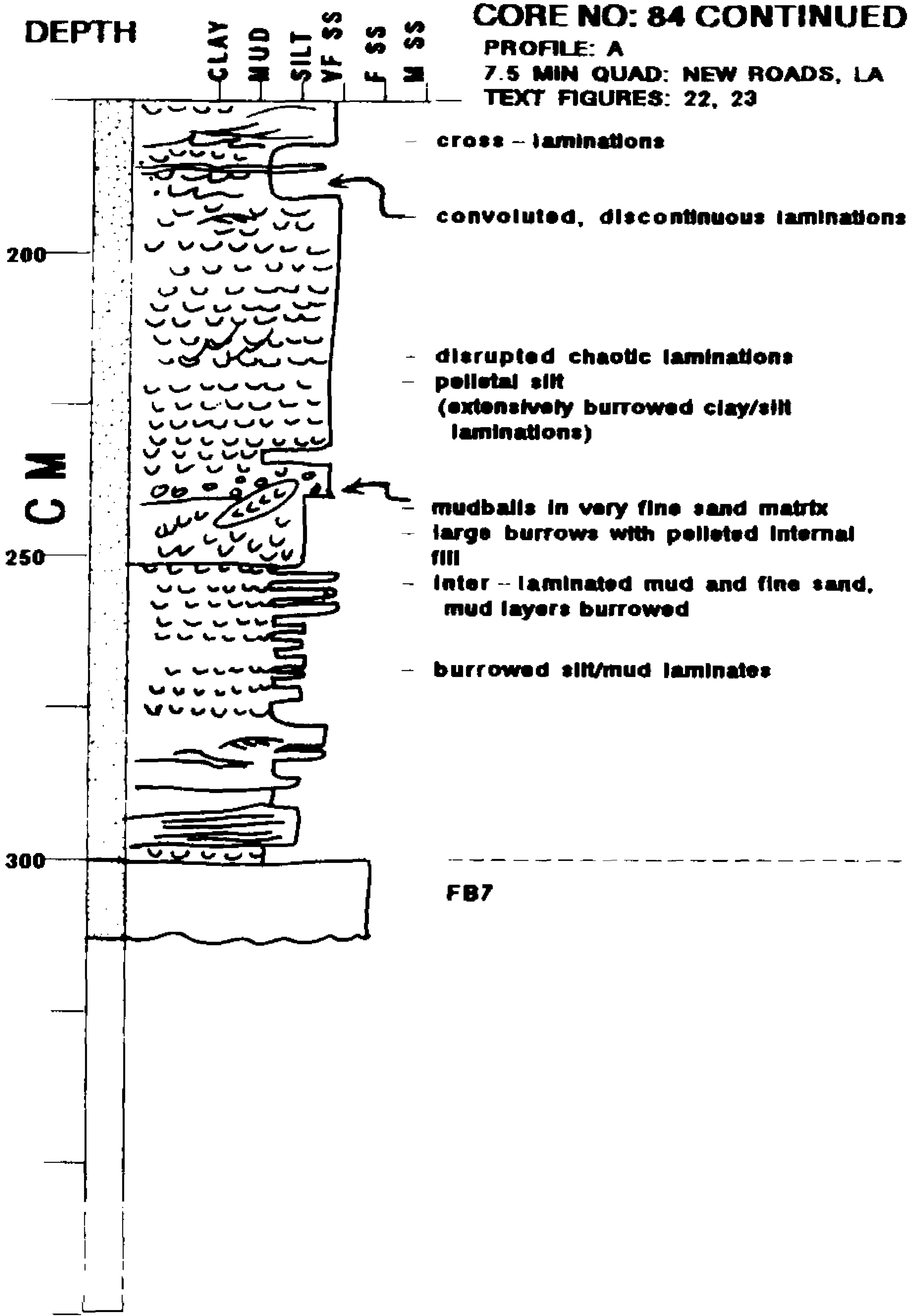
- flame structures at the tops of many beds

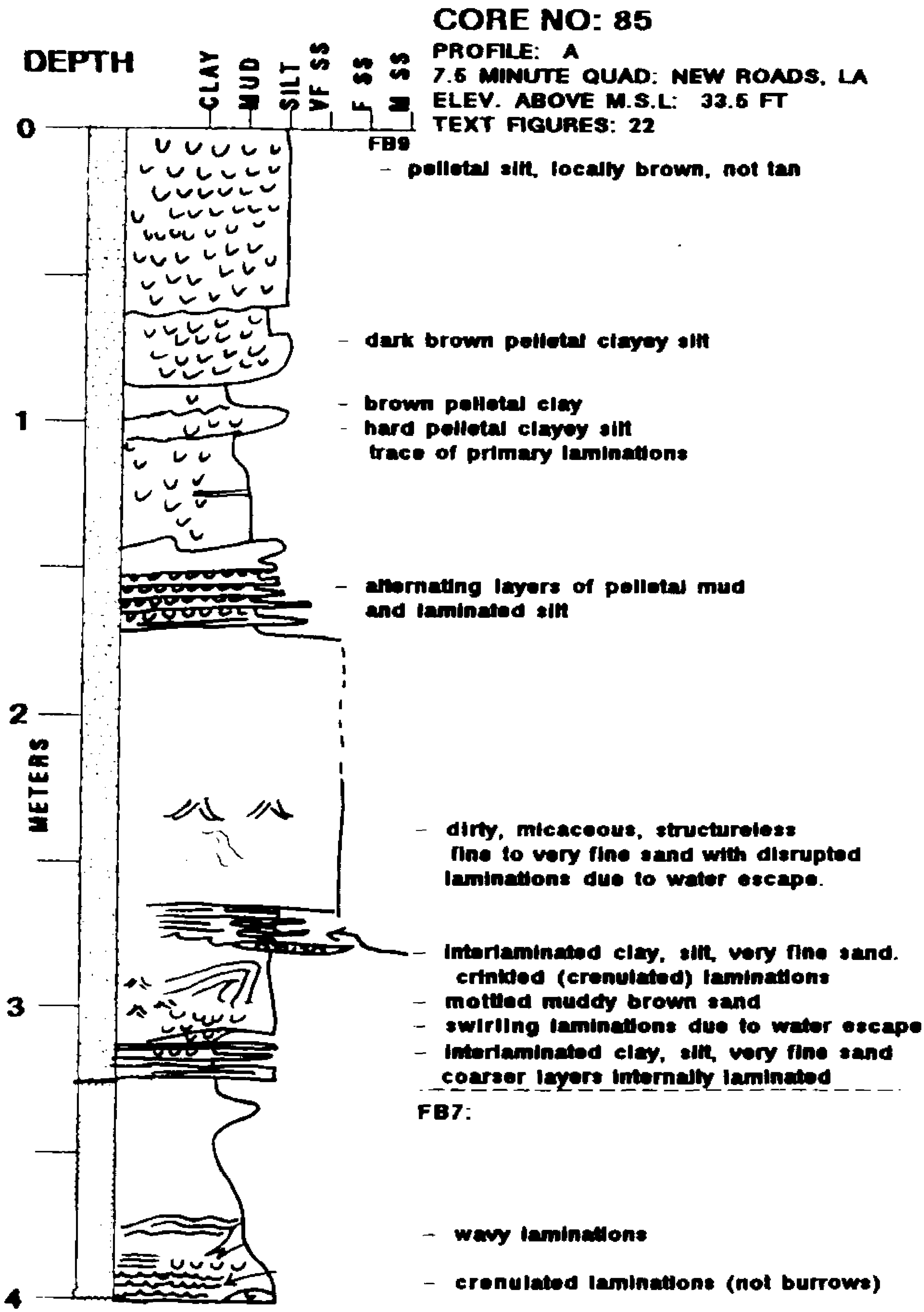
- discontinuous laminations, burrows
- flame structures at tops of muddy beds

CONTINUED

EXPANDED LOG
CORE NO: 84 CONTINUED

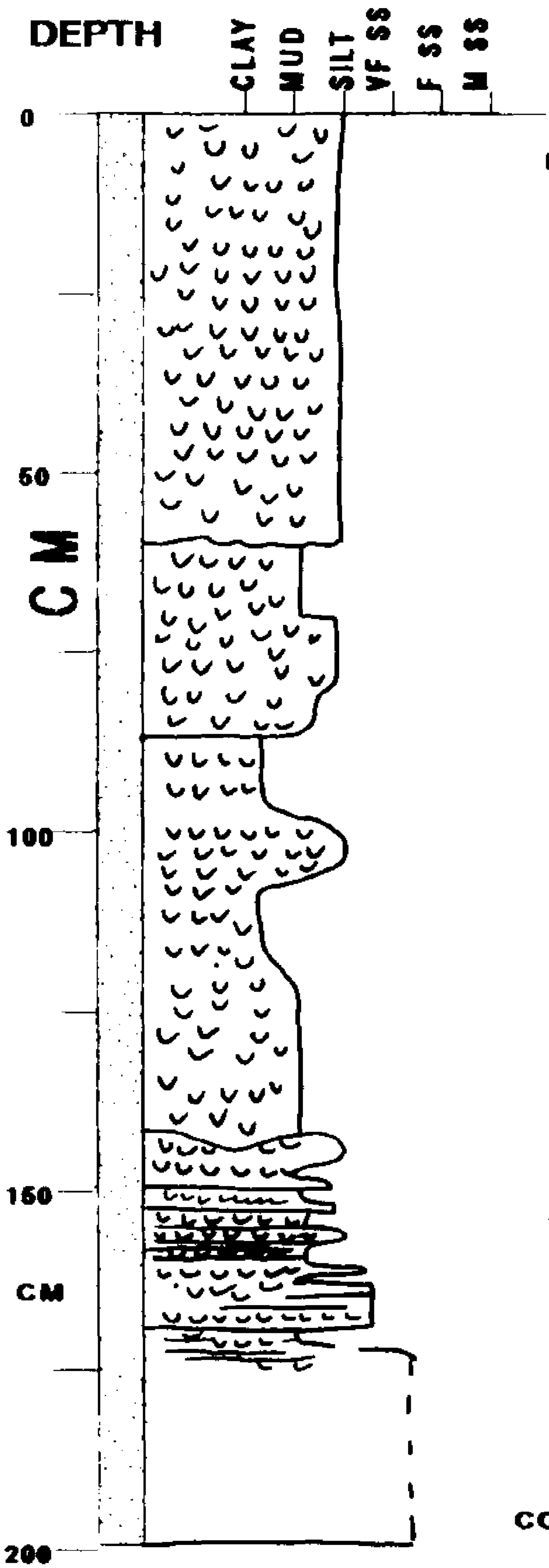
PROFILE: A
7.5 MIN QUAD: NEW ROADS, LA
TEXT FIGURES: 22, 23




CORE NO: 85
PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 33.5 FT
TEXT FIGURES: 22
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
0
1
2
3
4
METERS
FB9
- pelletal silt, locally brown, not tan
- dark brown pelletal clayey silt
- brown pelletal clay
- hard pelletal clayey silt
trace of primary laminations
- alternating layers of pelletal mud
and laminated silt
- dirty, micaceous, structureless
fine to very fine sand with disrupted
laminations due to water escape.
- interlaminated clay, silt, very fine sand.
crinkled (crenulated) laminations
- mottled muddy brown sand
- swirling laminations due to water escape
- interlaminated clay, silt, very fine sand
coarser layers internally laminated
FB7:
- wavy laminations
- crenulated laminations (not burrows)

EXPANDED LOG
CORE NO: 85

PROFILE: A
7.5 MIN QUAD: NEW ROADS, LA
TEXT FIGURES: 22



FB9: previous page

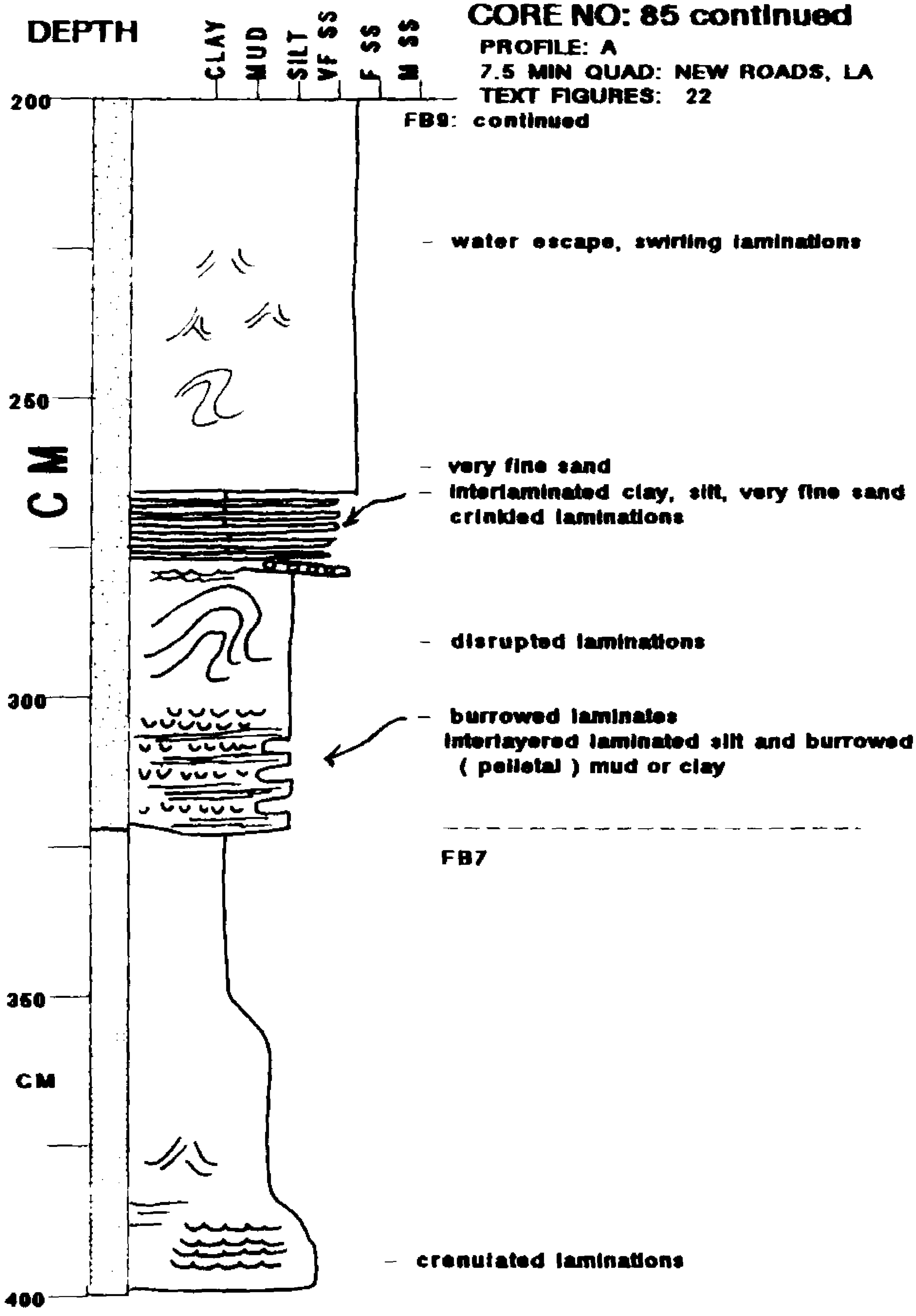
– various pelletal lithologies

– interlayered burrowed mud and laminated silt or sand.

CONTINUED

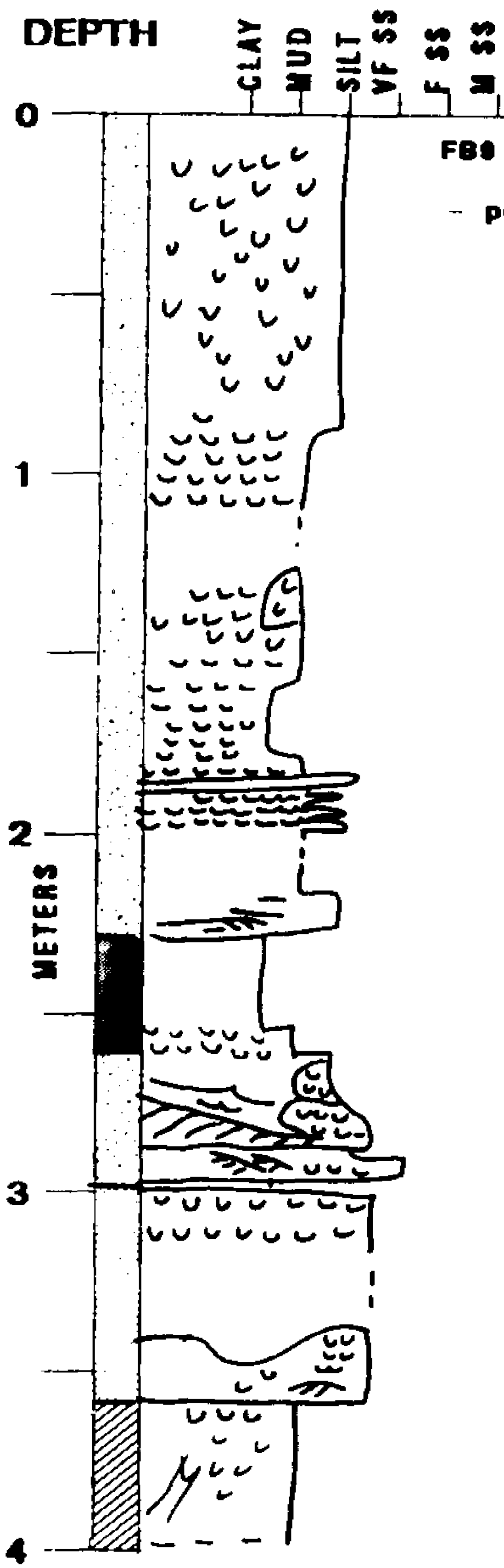
EXPANDED LOG
CORE NO: 85 continued

PROFILE: A
7.5 MIN QUAD: NEW ROADS, LA
TEXT FIGURES: 22



CORE NO: 86

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 32 FT
TEXT FIGURES: 22, 37



FB9 (expanded on next page)

– pelletal silt with minor silty rhythmites

FB4: rooted clay

FB9: pelletal silt with large cross-cutting burrows with pelletal internal fill
ripple laminations, ripple drift

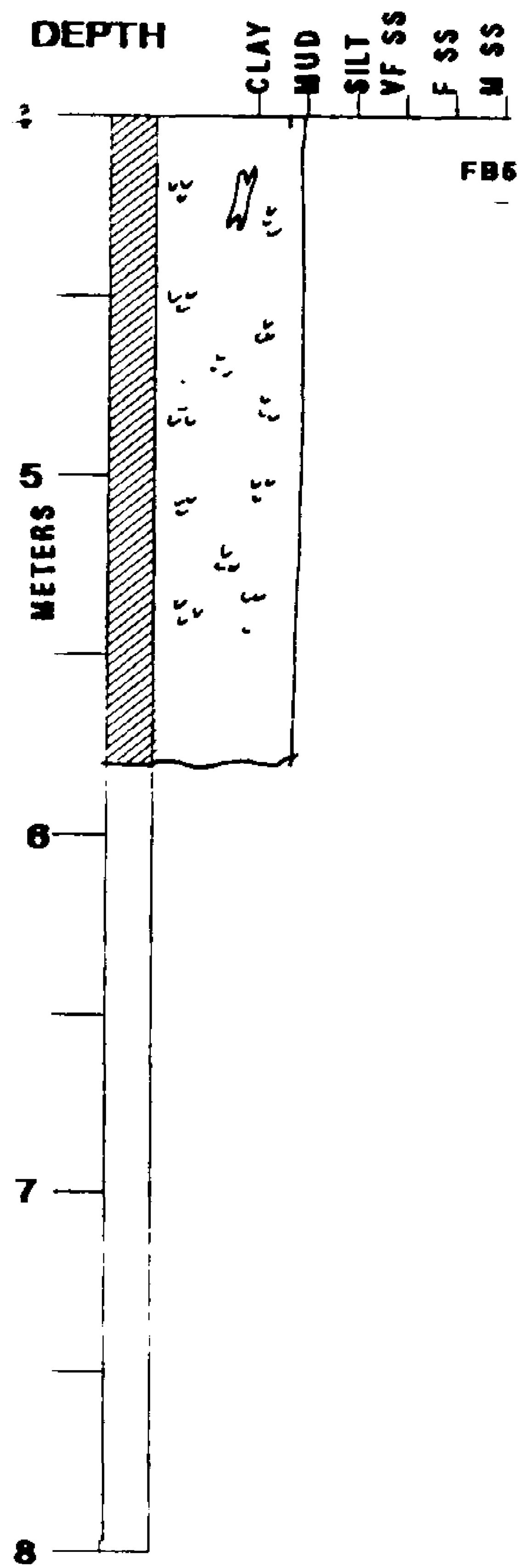
FB7: pelletal silt

FB5: bluish-gray clayey silt and mud.

CONTINUED

CORE NO: 86 continued

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 32 FT
TEXT FIGURES: 22, 37

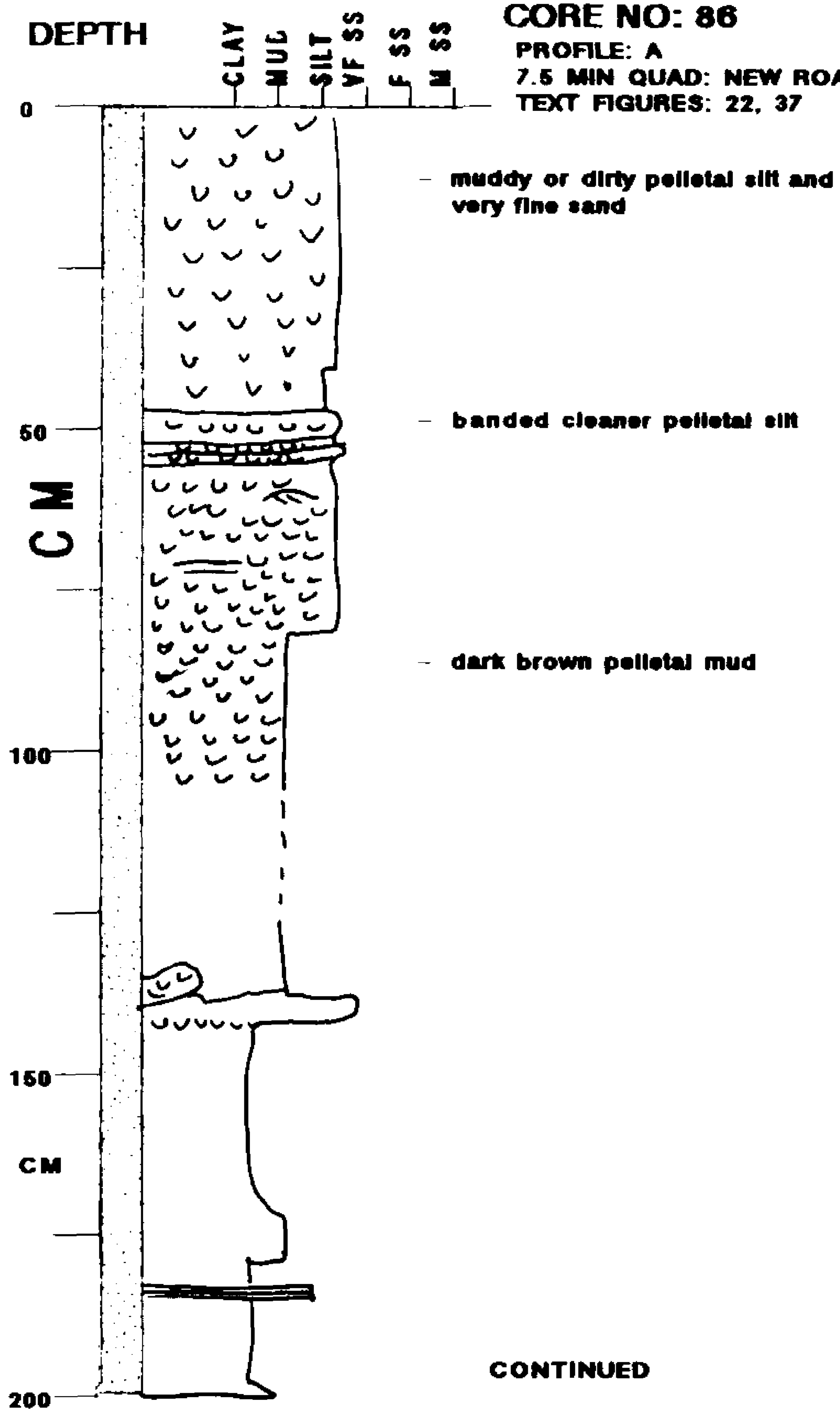


FB5:

- **bluish gray mud, clayey silt, silty clay includes pelletal fabric with granular Fe – oxides.**

EXPANDED LOG
CORE NO: 86

PROFILE: A
7.5 MIN QUAD: NEW ROADS, LA
TEXT FIGURES: 22, 37



CONTINUED

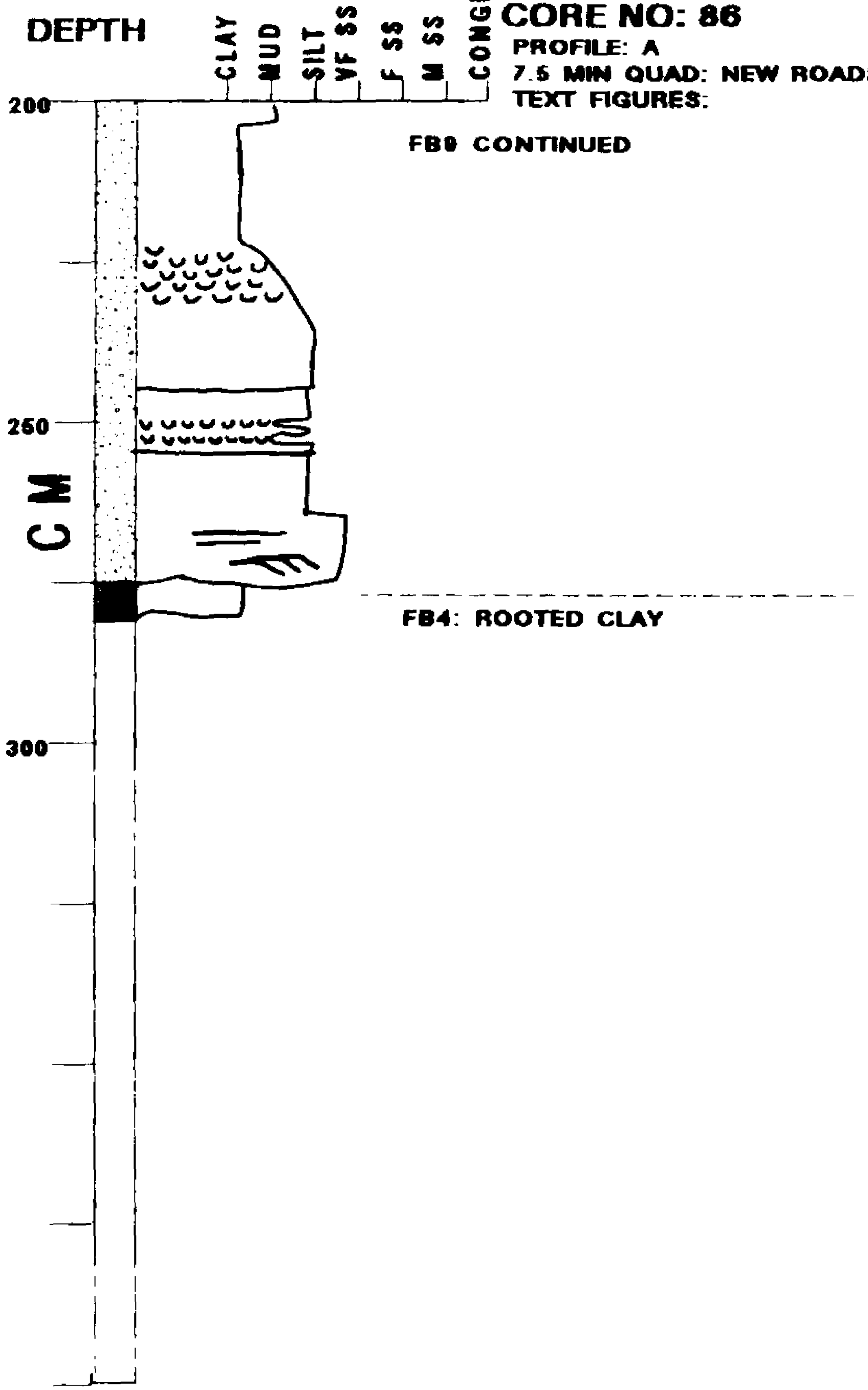
EXPANDED LOG

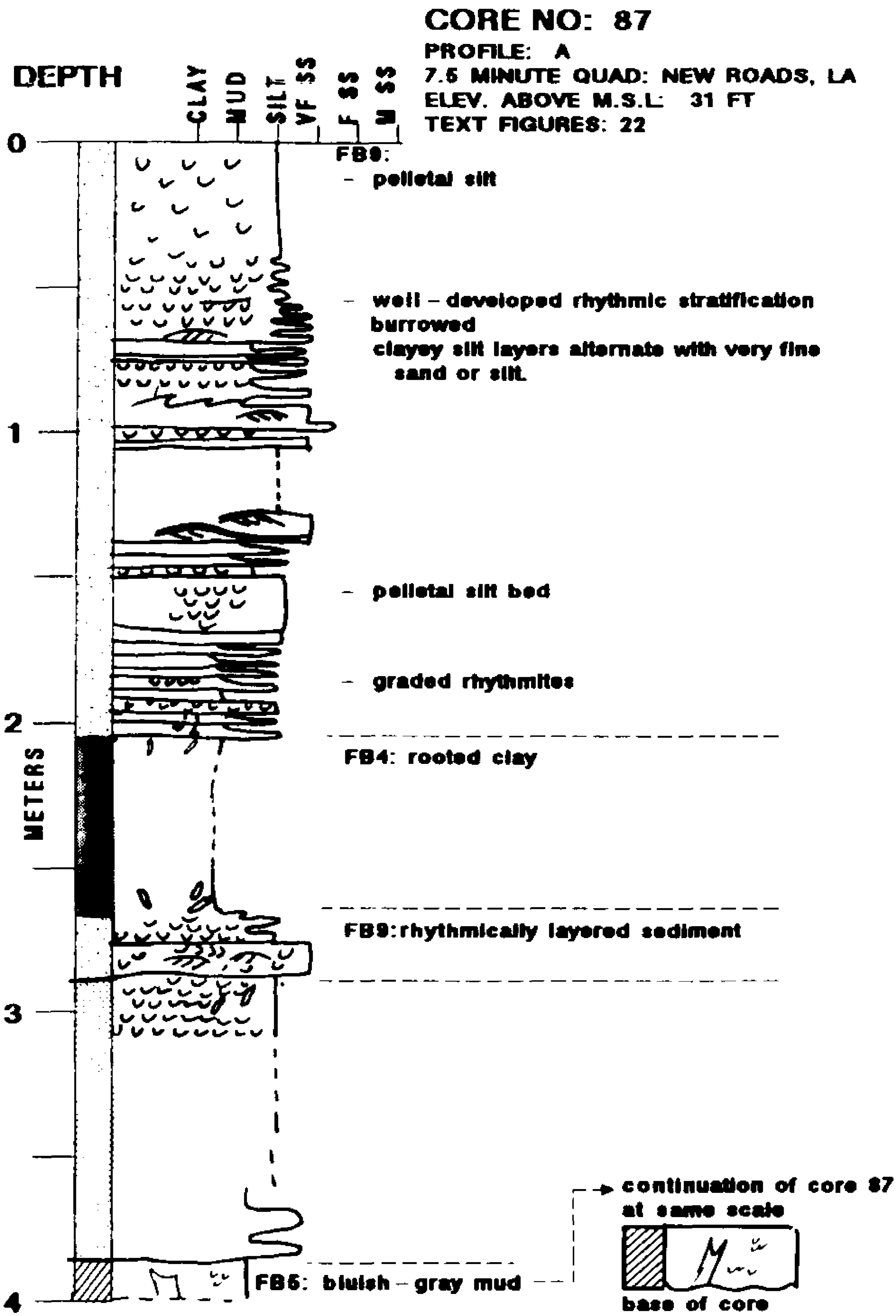
CORE NO: 86

PROFILE: A

7.5 MIN QUAD: NEW ROADS, LA

TEXT FIGURES:



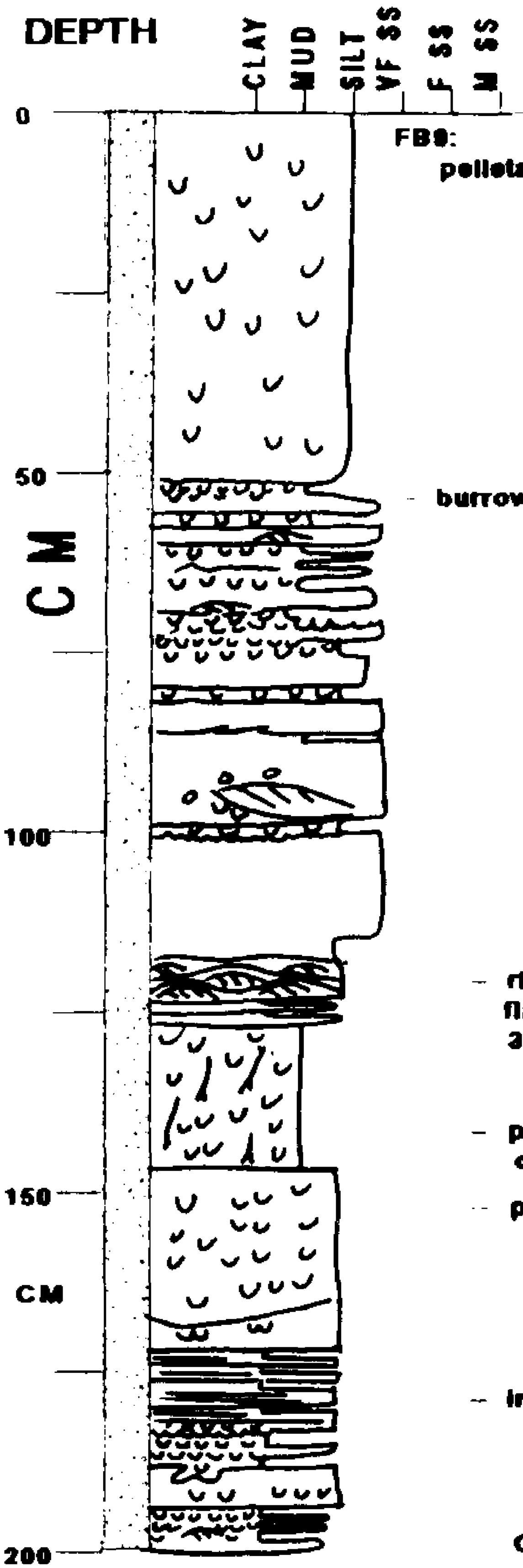


CORE NO: 87
PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 31 FT
TEXT FIGURES: 22
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
0
1
2
3
4
METERS
FB9:
- pelletal silt
- well - developed rhythmic stratification
burrowed
clayey silt layers alternate with very fine sand or silt.
- pelletal silt bed
- graded rhythmites
FB4: rooted clay
FB9: rhythmically layered sediment
FB5: bluish - gray mud
continuation of core 87 at same scale
base of core

EXPANDED LOG

CORE NO: 87

PROFILE: A
7.5 MIN QUAD: NEW ROADS, LA
TEXT FIGURES: 22



FB9:
pelletal silt

– burrowed silty rhythmites

– ripple forms separated by clay drapes, flaser bedding
3 graded rhythmite layers

– pelletal silt, mud, dark brown with coated root hairs

– pelletal silt

– interlayered clay and very fine sand/ coarse silt.
coarser layers are laminated internally

CONTINUED

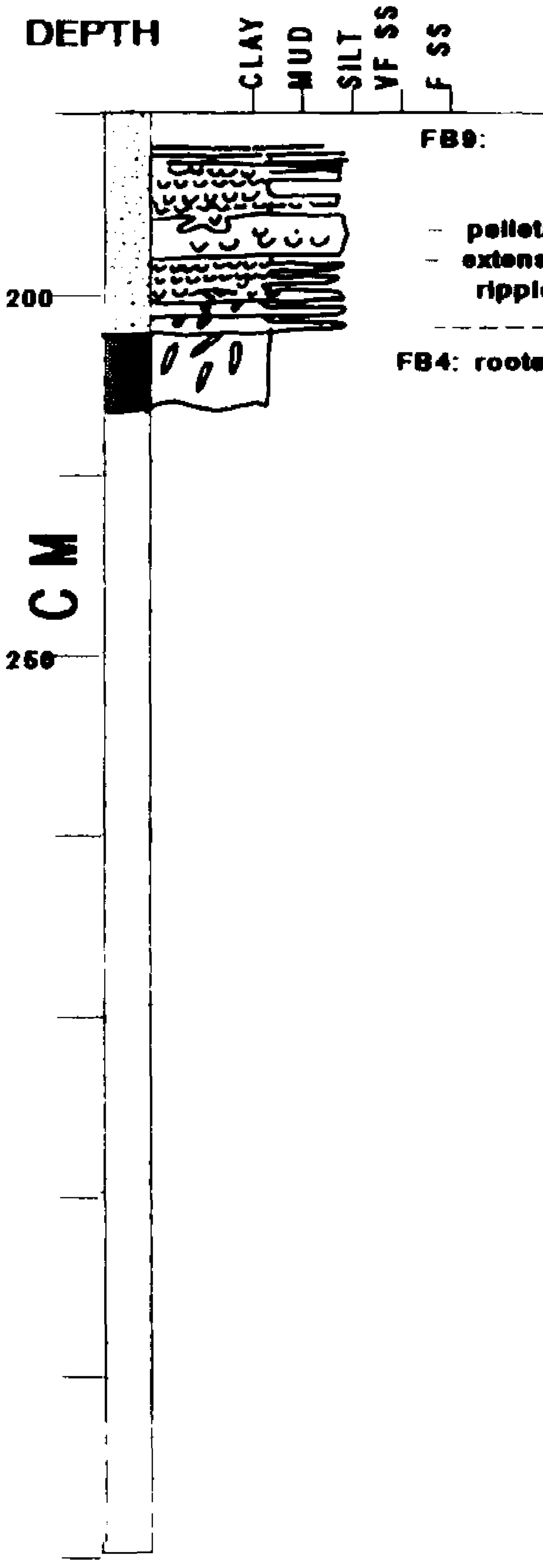
EXPANDED LOG

CORE NO: 87 continued

PROFILE: A

7.5 MIN QUAD: NEW ROADS, LA

TEXT FIGURES: 22



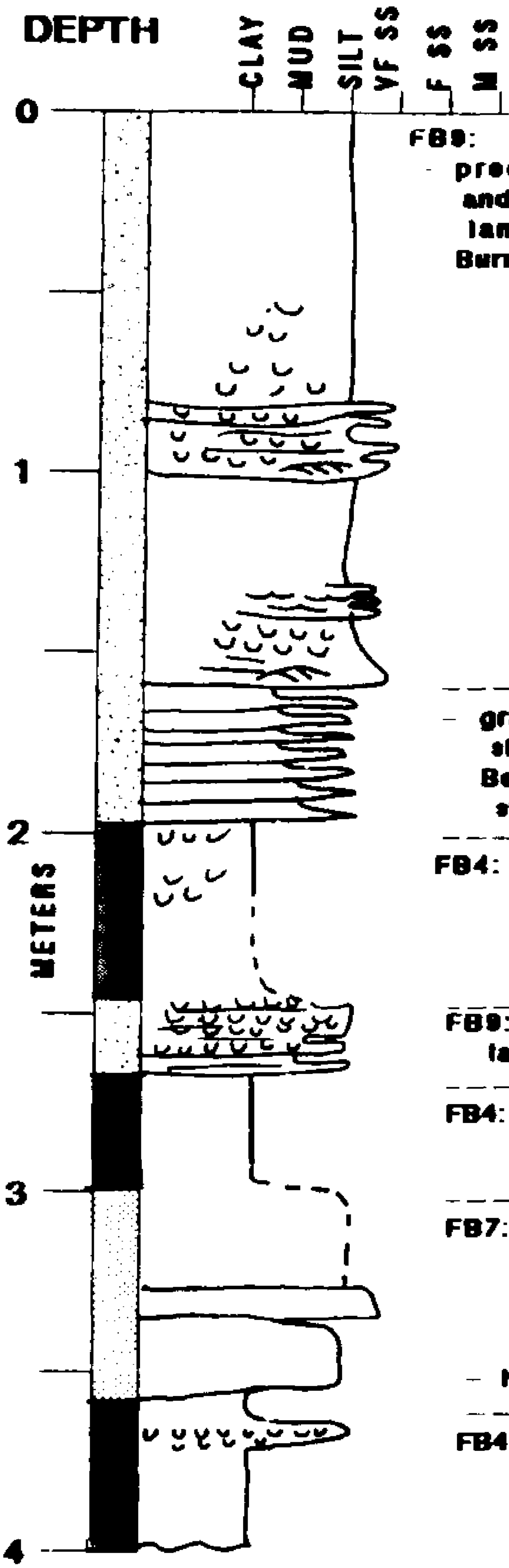
FB9:

- **pelletal silt**
- **extensively burrowed silty rhythmites, ripple laminations dip towards flood basin.**

FB4: rooted clay

CORE NO: 88

PROFILE: A
7.5 MINUTE QUAD: NEW ROADS, LA
ELEV. ABOVE M.S.L: 30 FT
TEXT FIGURES: 22



FB9:
- predominantly pelletal silt with minor sandy and silty rhythmites. Traces of parallel laminations and ripple laminations. Burrowing is pervasive.

- graded rhythmites, unburrowed with sharp contacts between graded layers. Beautiful preservation of primary stratification

FB4: clay, grayish brown, pelletal, rooted.

FB9: pelletal silty and sandy rhythmites with laminated sand layers

FB4: gray rooted clay

FB7:

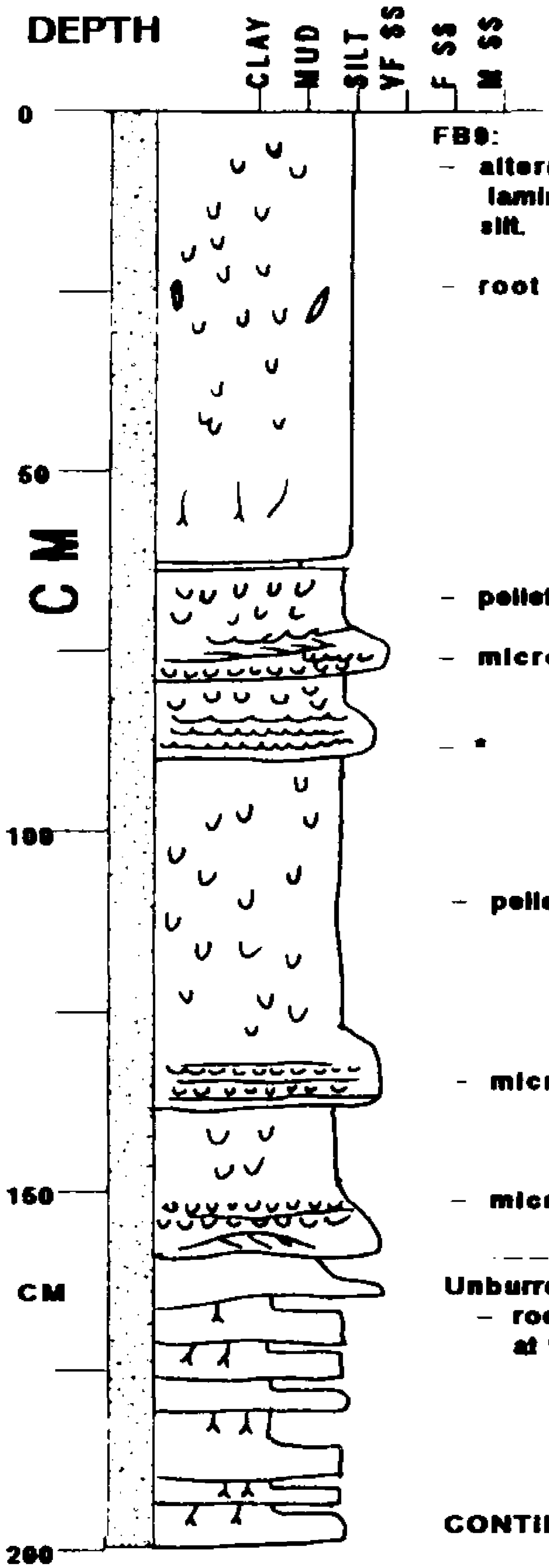
- hard, massive clayey silt

FB4: rooted clay with pelletal silt layer

EXPANDED LOG

CORE NO: 88

PROFILE: A
7.5 MIN QUAD: NEW ROADS, LA
TEXT FIGURES: 22



FB9:

- alternating zones of burrowed laminated, laminated silt and massive pelletal clayey silt.
- root hairs lined with Fe – oxide.
- pelletal silt
- micropelletal laminates*
- * * interlaminated clay and silt where clay layer is burrowed into pelletal fabric and silt layer is laminated internally. Each layer is only several MM thick.
- pelletal silt
- micropelletal laminates
- micropelletal laminates

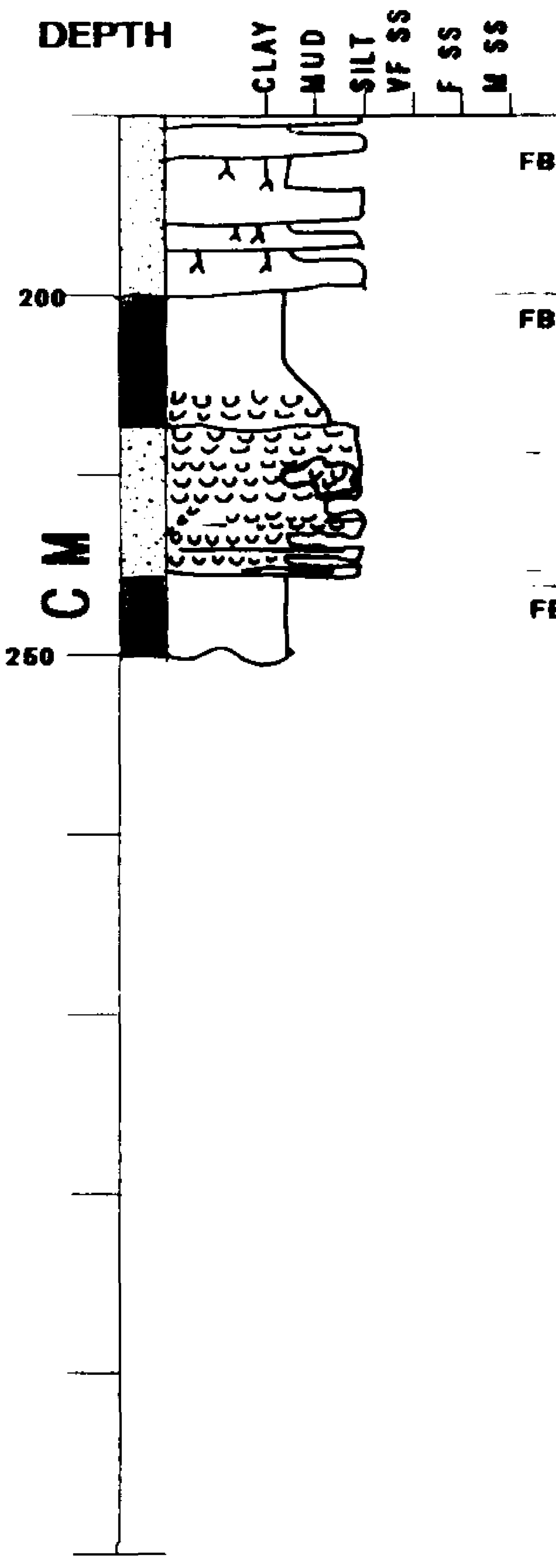
Unburrowed graded rhythmites

- roots or burrows? terminated upwards at the base of overlying graded layer.

CONTINUED

EXPANDED LOG
CORE NO: 88

PROFILE: A
7.5 MIN QUAD: NEW ROADS, LA
TEXT FIGURES: 22



FB9: graded rhythmites

FB4: rooted clay

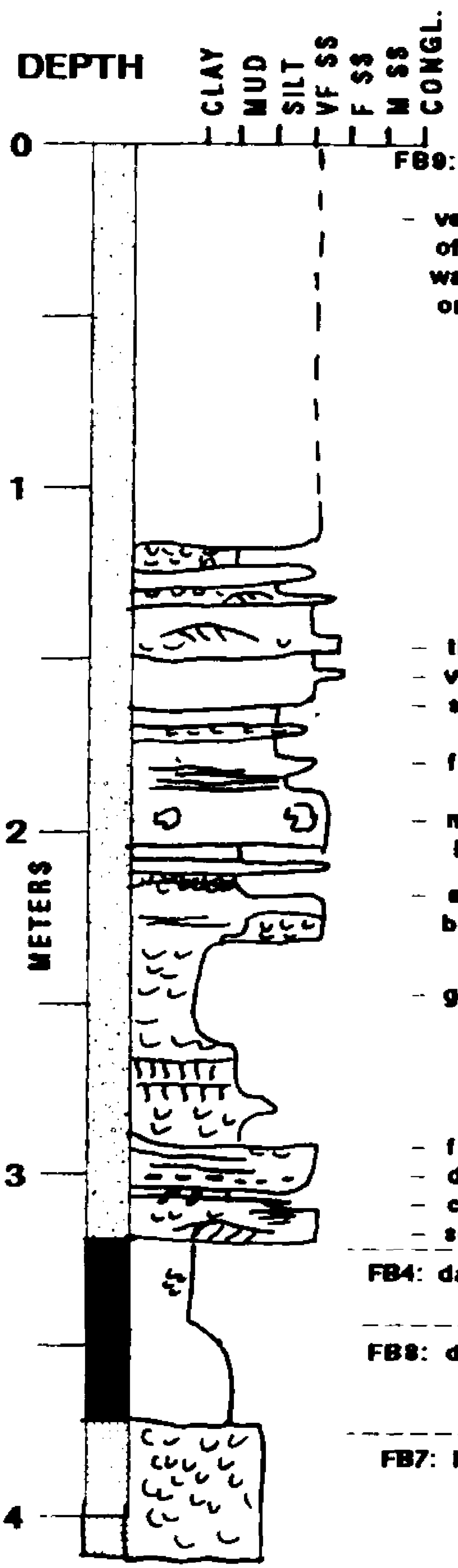
- interlaminated silt and brown clay, burrowed along clay laminations

- silty rhythmites, micropelletal

FB4: rooted clay

CORE NO: 99

PROFILE: D
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 34.5 FT
TEXT FIGURES: 30



FB9:

- very sandy, loose sediment, lost out of unstable core tube. Indicates that sand was very well sorted and lacked little clay or mud.

- tiny ripple laminations
- very fine silty sand
- sandy silt
- faint laminations
- mottles, very fine well-sorted sand with light gray muddy sand mottles.
- extensive mottling due to large cross-cutting burrows with pelletal internal fill.
- gray pelletal clay
- faint laminations
- detrital organics, root linings
- cross-stratification, parallel laminations
- scour and fill

FB4: dark gray clay

FB8: dark brown pelletal mud

FB7: hard clayey pelletal silt

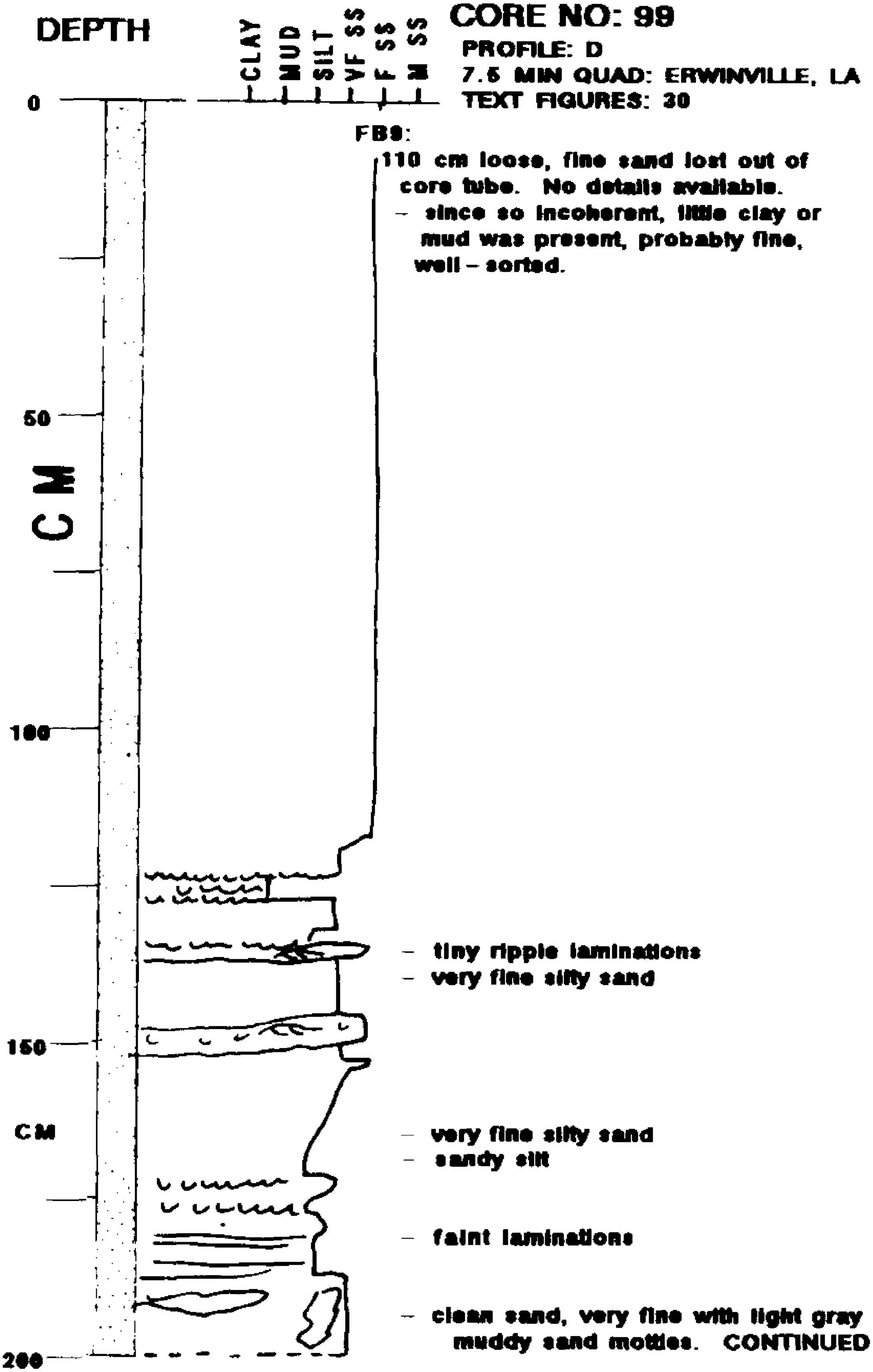
EXPANDED LOG

CORE NO: 99

PROFILE: D

7.5 MIN QUAD: ERWINVILLE, LA

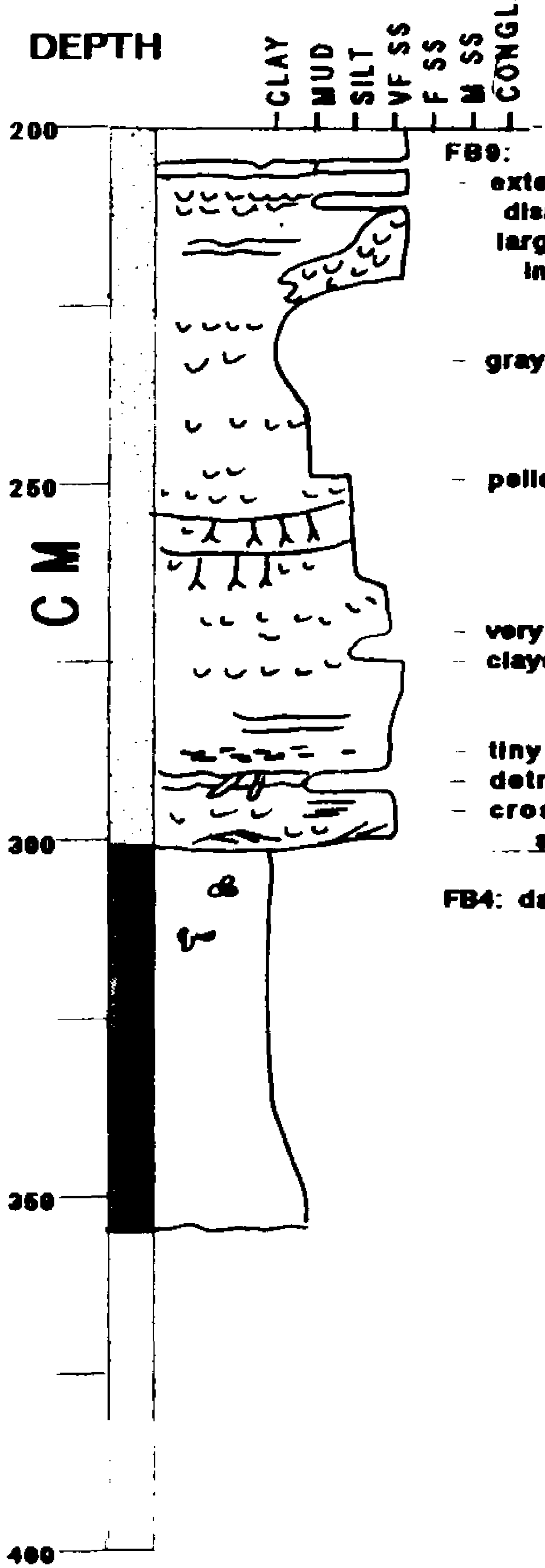
TEXT FIGURES: 30



EXPANDED LOG

CORE NO: 99

PROFILE: D
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 30

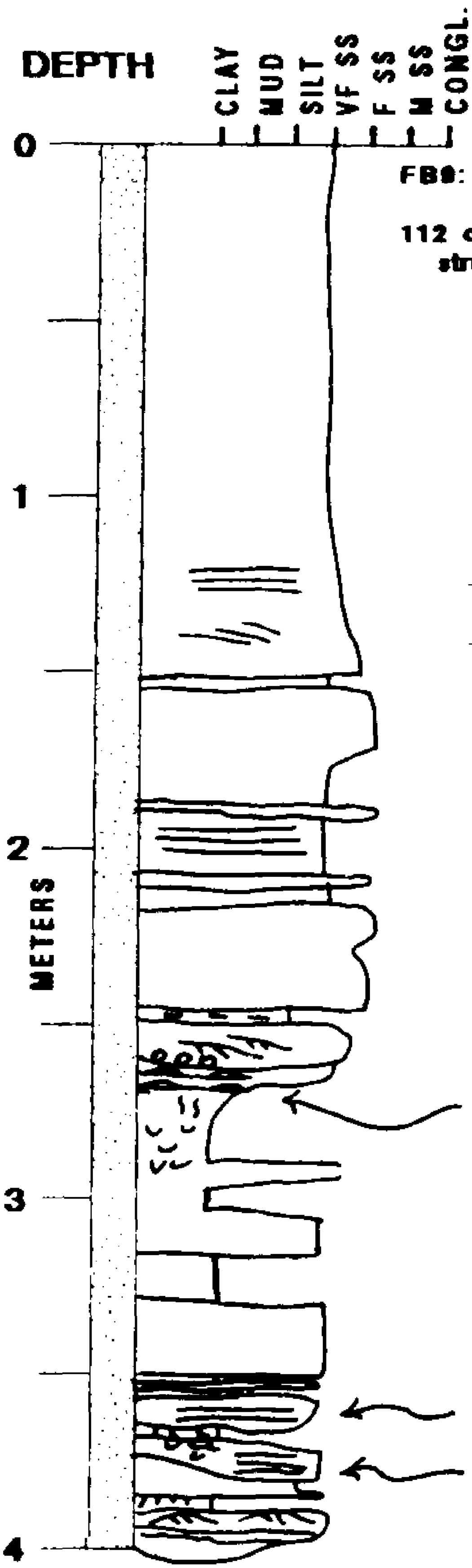


FB9:
- extensive mottling, disrupted contacts, disrupted fine laminations, large cross – cutting burrows with pelletal internal fill.
- gray clay, pelletal
- pelletal clayey silt with granular Fe – oxides
- very fine silty sand, slightly clayey
- clayey silt
- tiny faint laminations
- detrital organics, root linings
- cross – stratification
  scour and fill

FB4: dark gray clay

CORE NO: 100

PROFILE: D
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 37 FT
TEXT FIGURES: 30



FBS:

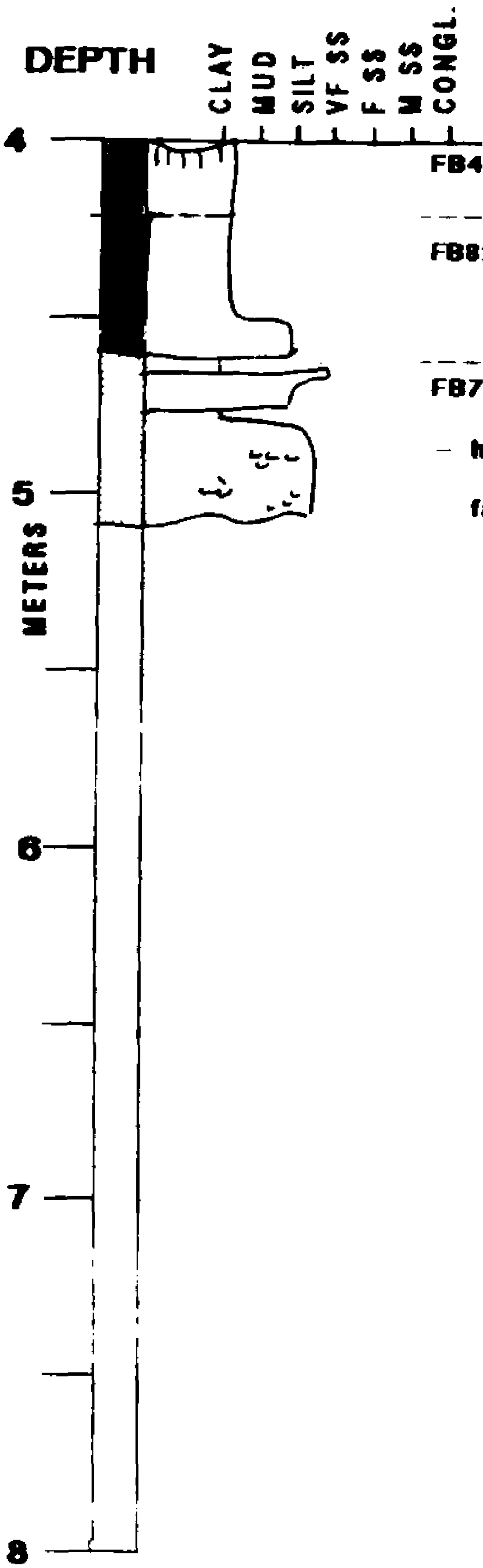
112 cm very fine silty sand lacking mud structureless

- **trace of clay, trace of laminations**
- **dark lines between white sand layers slightly inclined parallel laminations**
- **parallel laminations**
- **detrital organics**
- **very fine silty sand**
- **clay ripup clasts**
- **lenticular bedding**
- **crenulated parallel laminations**
- **disrupted laminations**
- **very fine silty sand**
- **tiny ripple laminations**
- **very fine silty soft sand**

CONTINUED

CORE NO: 100 continued

PROFILE: D
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 37 FT
TEXT FIGURES: 30



FB4: rooted clay

FB8: dark brown mud and clay

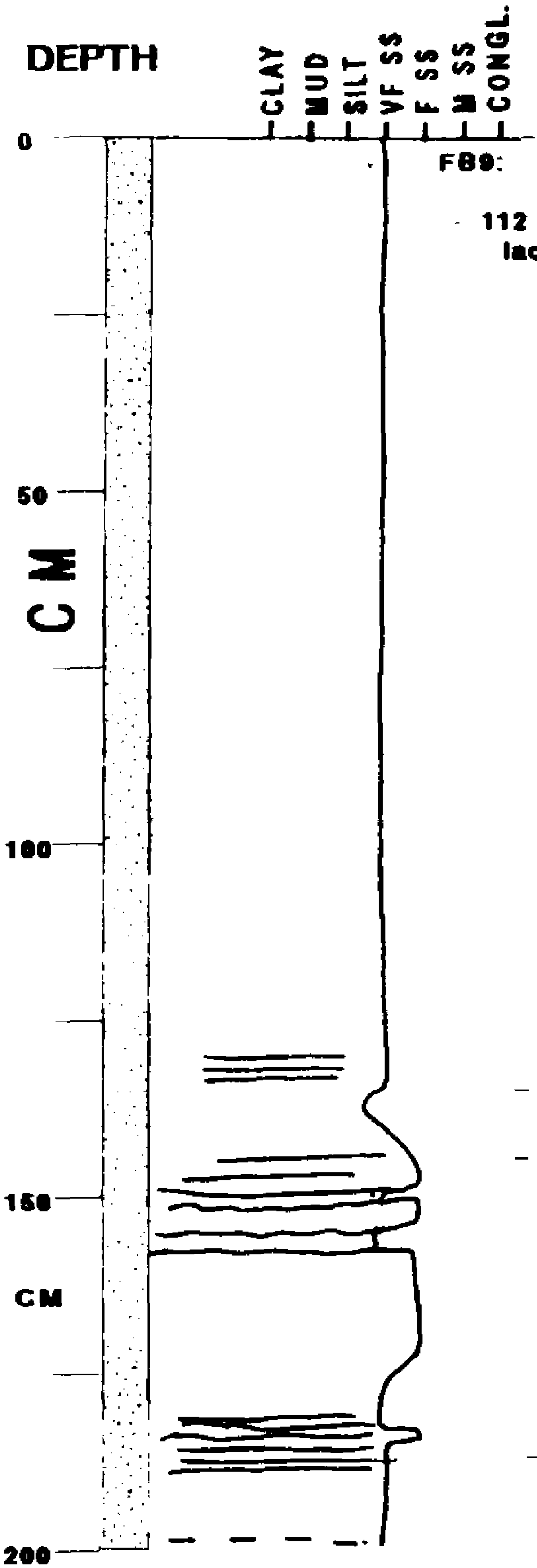
FB7:

- **hard, very fine clayey sand and clayey silt with granular Fe – oxide concretions and pelletal fabric.**

EXPANDED LOG

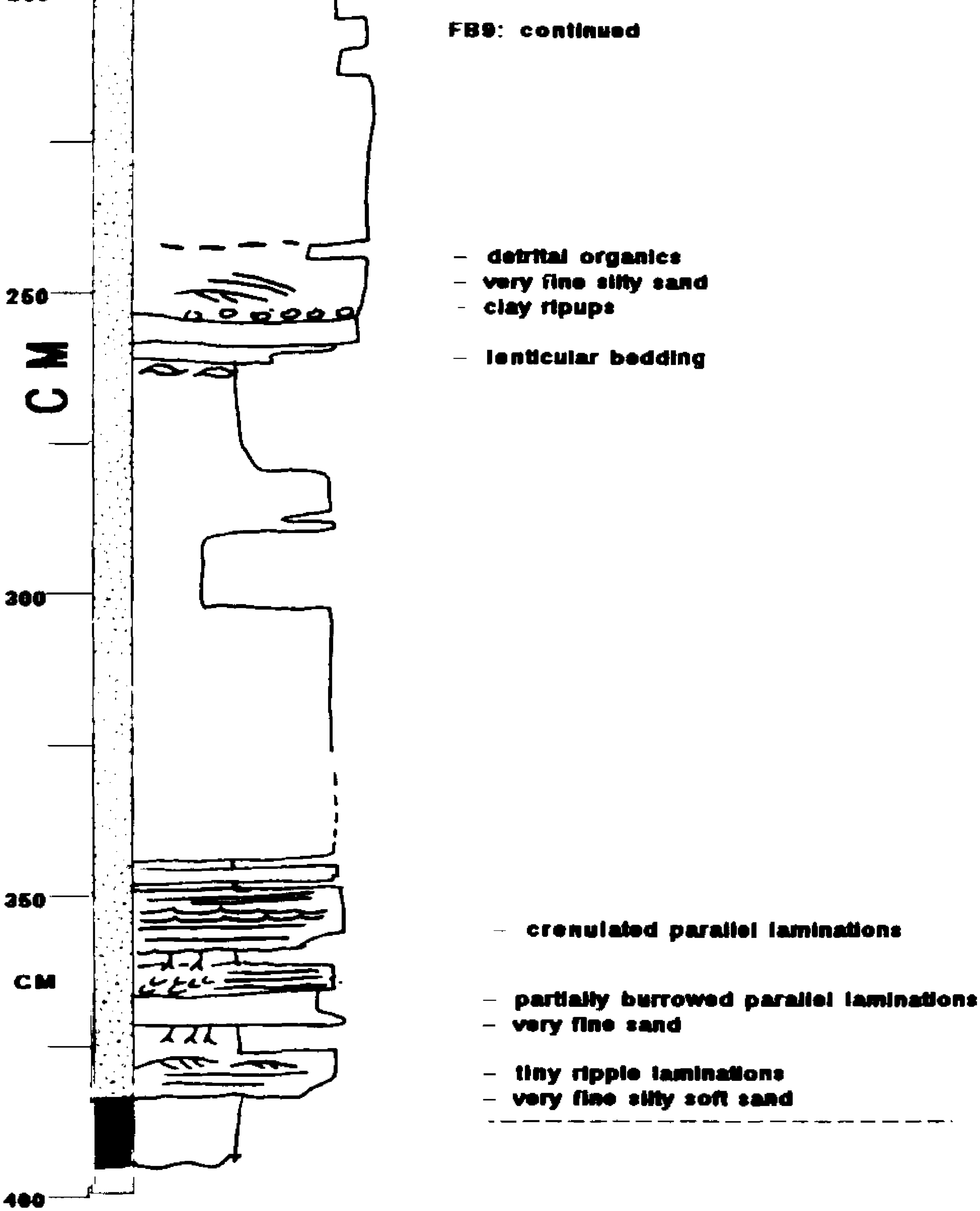
CORE NO: 100

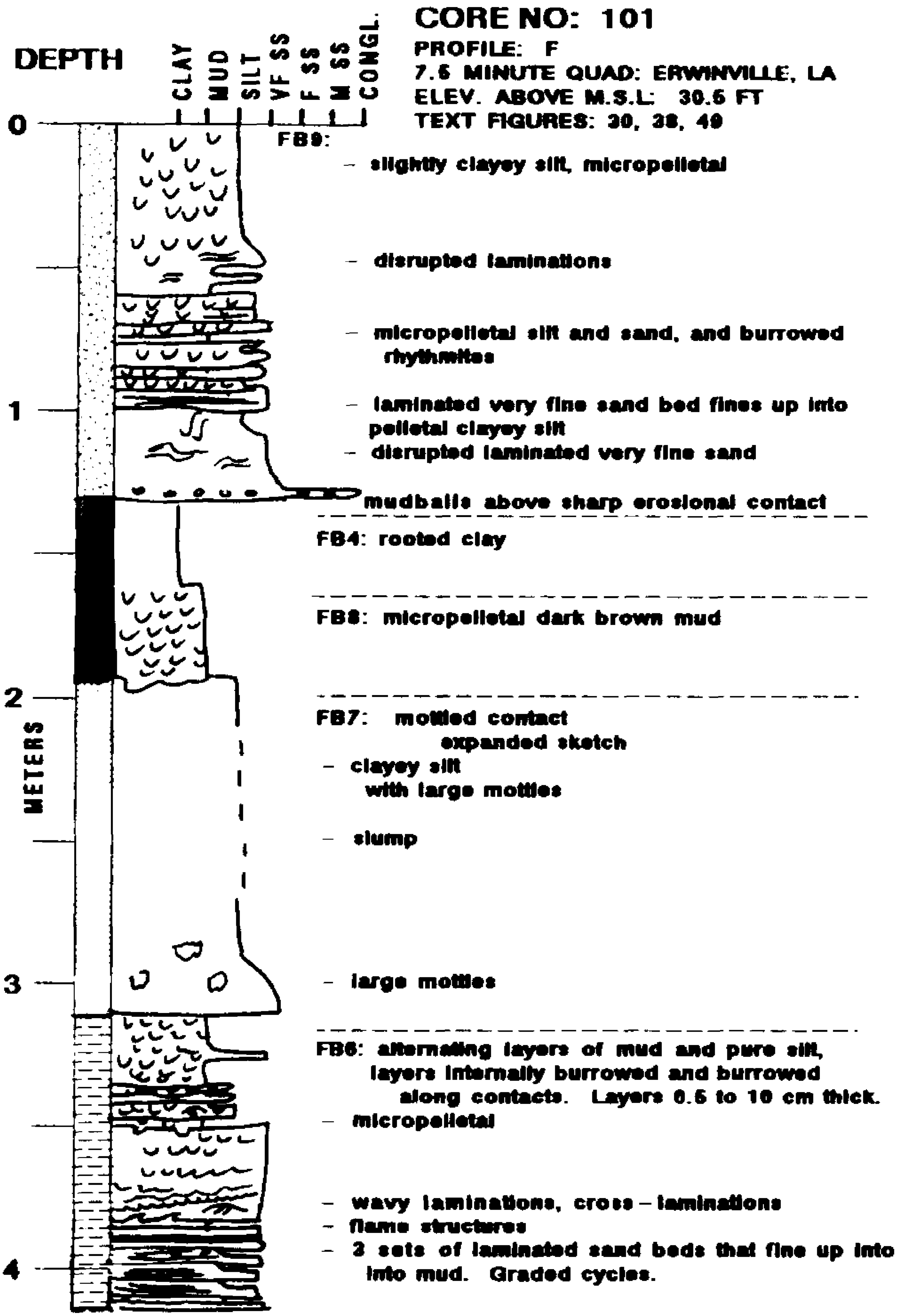
PROFILE: D
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 30



EXPANDED LOG
CORE NO: 100 Continued

PROFILE: D
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 30




CORE NO: 101
PROFILE: F
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 30.5 FT
TEXT FIGURES: 30, 38, 49
DEPTH
CLAY
MUD
SILT
VF SS
F SS
M SS
CONGL.
0
1
2
3
4
METERS
FB9:
– slightly clayey silt, micropelletal
– disrupted laminations
– micropelletal silt and sand, and burrowed rhythmites
– laminated very fine sand bed fines up into pelletal clayey silt
– disrupted laminated very fine sand
mudballs above sharp erosional contact
FB4: rooted clay
FB8: micropelletal dark brown mud
FB7: mottled contact
expanded sketch
– clayey silt
with large mottles
– slump
– large mottles
FB6: alternating layers of mud and pure silt, layers internally burrowed and burrowed along contacts. Layers 0.5 to 10 cm thick.
– micropelletal
– wavy laminations, cross – laminations
– flame structures
– 3 sets of laminated sand beds that fine up into into mud. Graded cycles.

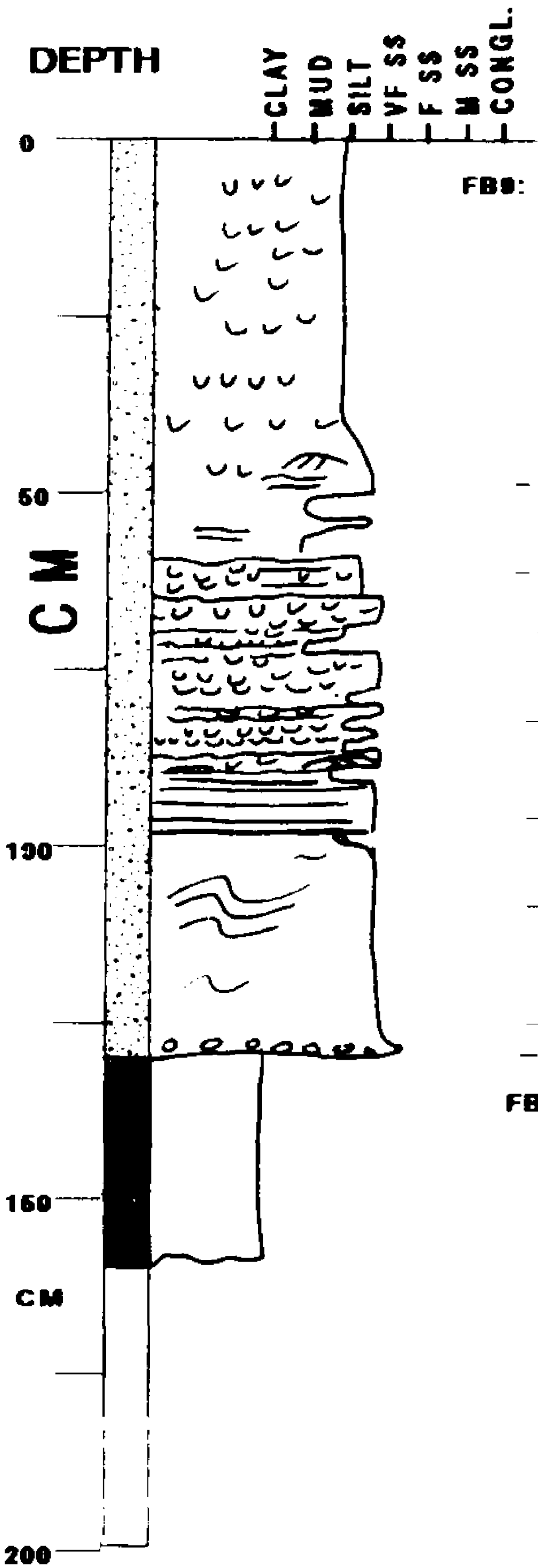
EXPANDED LOG

CORE NO: 101

PROFILE: F

7.5 MIN QUAD: ERWINVILLE, LA

TEXT FIGURES: 30, 38, 49



FB9: silt, slightly clayey, micropelletal

– disrupted laminations, mud drapes

– micropelletal rhythmites and pelletal silt
 – sandier zones exhibit disrupted laminae
 – silty very fine sand

– clayey silt

– parallel laminated very fine sand fines up into laminated silt

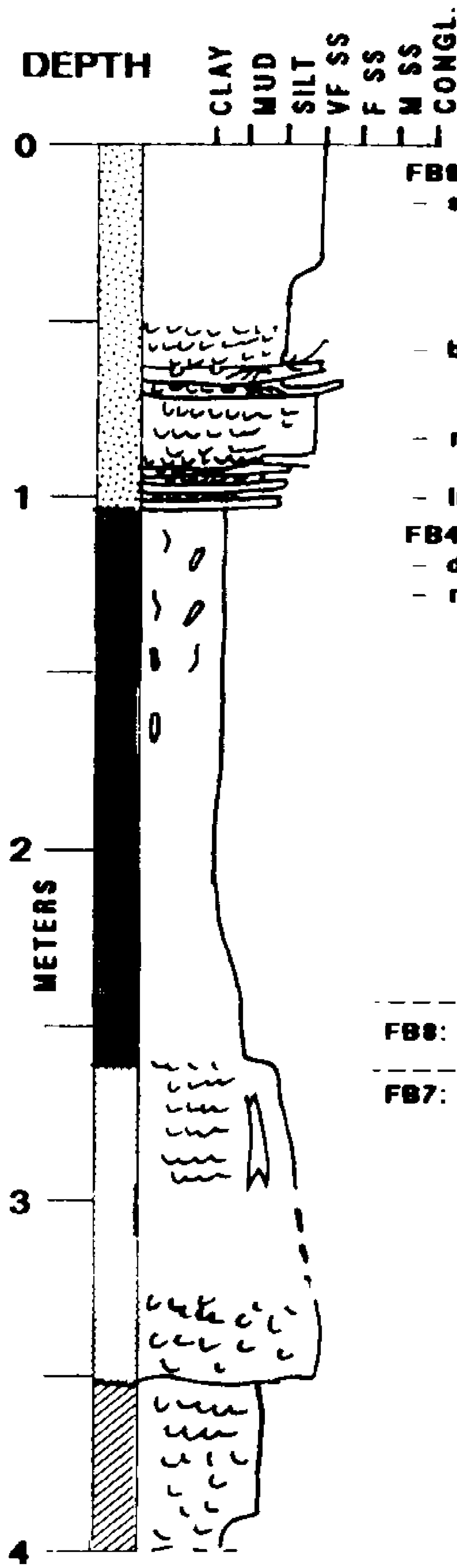
– disrupted laminations in very fine sand.

– sharp contact with mudballs above it

FB4: rooted clay

CORE NO: 102

PROFILE: G
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 25.5 FT
TEXT FIGURES: 30



FB9:
- silty very fine sand, structureless
- burrowed contact. Pelletal fabric starts here.
- micropelletal sand and silt
- interlaminated pelletal silt and clay or mud

FB4:
- dark brown clay
- root hairs, some have Fe-oxide coatings

FB8: dark brown pelletal mud

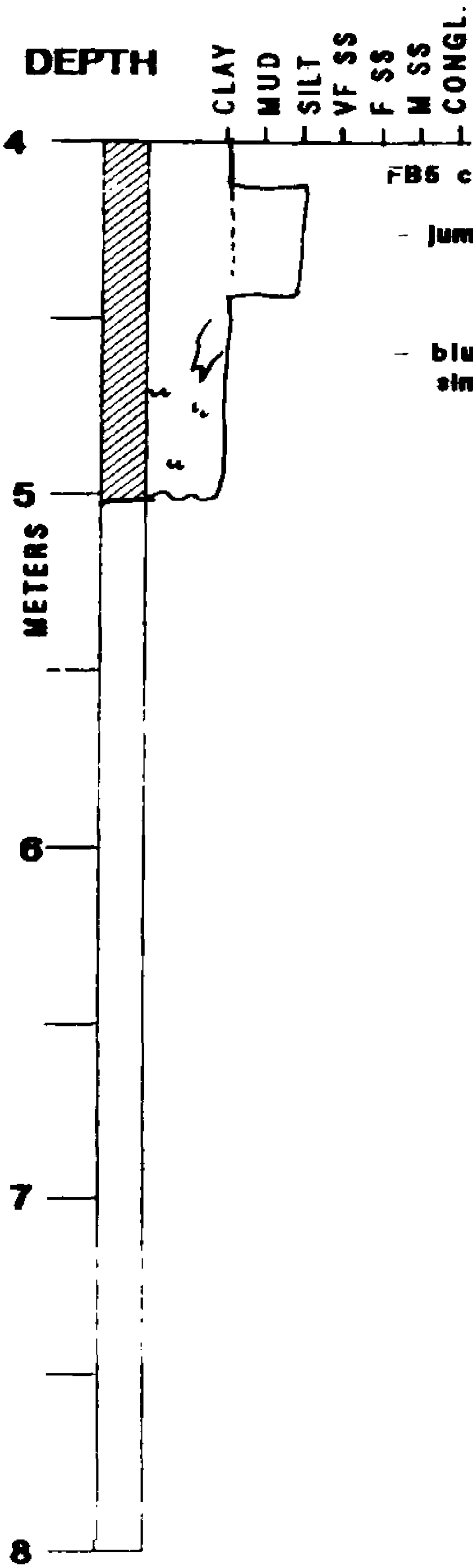
FB7: hard clayey sand and sandy clay, pelletal

- micropelletal silt and sand

FB5: rooted pelletal clay and mud similar to FB4

CORE NO: 102 continued

PROFILE: G
7.5 MINUTE QUAD: ERWINVILLE, LA
ELEV. ABOVE M.S.L: 25.5 FT
TEXT FIGURES: 30



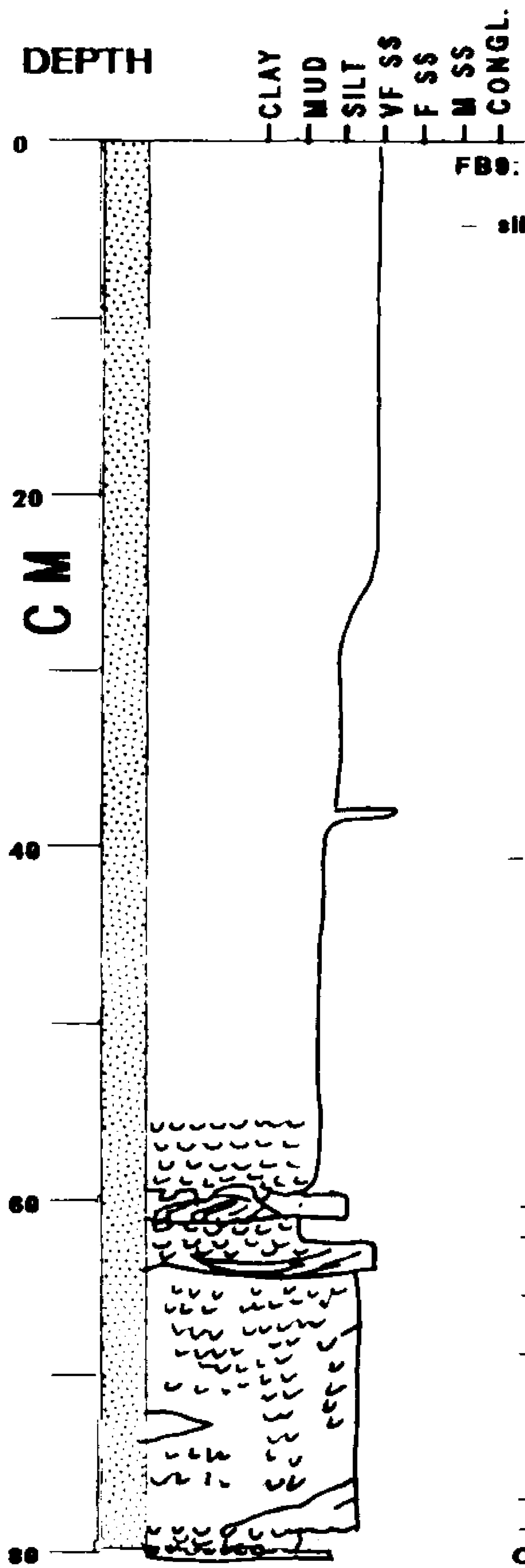
FB5 continued:

- jumbled mud/clay, artifact of coring

- bluish clay with orange mottling, similar to FB4

EXPANDED LOG
CORE NO: 102

PROFILE: G
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 30



– silty very fine sand

– hard slightly clayey silt

– sharp burrowed contacts
– layer made of single ripple cross – set ripple form preserved, draped.
– sharp contact

– silt, pelletal
rather chaotic appearing silt and sand with trace of clay mixed in.

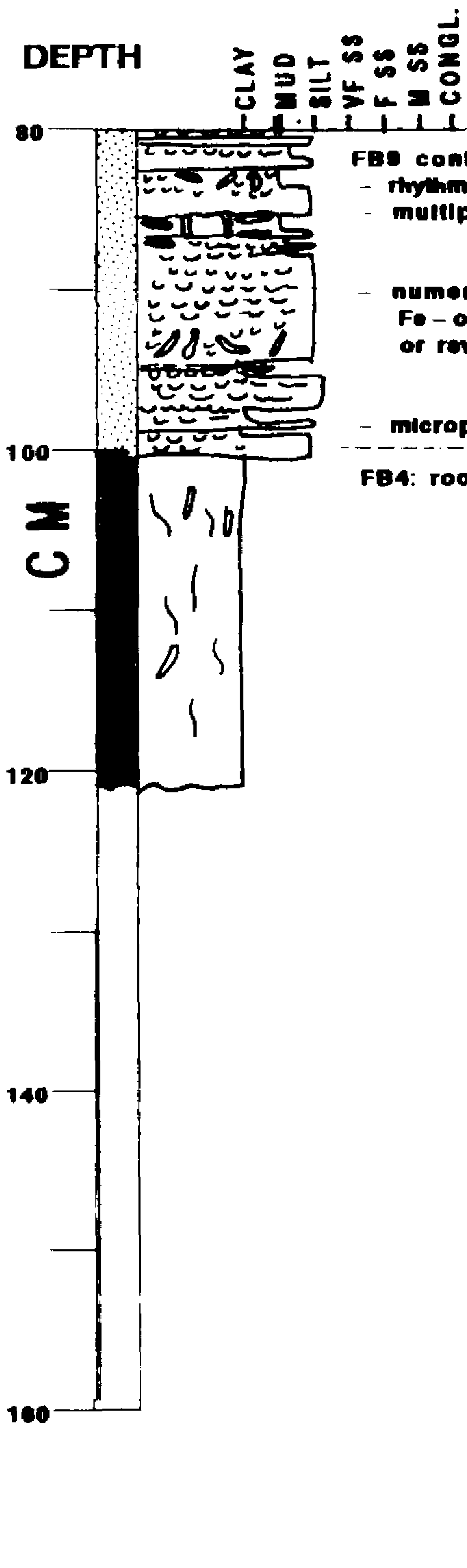
– very fine sand
– carbonate coated leaf fronds

CONTINUED

EXPANDED LOG

CORE NO: 102 continued

PROFILE: G
7.5 MIN QUAD: ERWINVILLE, LA
TEXT FIGURES: 30



FB9 continued:

- rhythmically layered
- multiple fining upward sequences
- numerous root segments with linings of Fe – oxides, either semi – vertical (in place) or reworked and horizontally inclined.
- micropelletal fabric pervasive

FB4: rooted clay

VITA

Kathleen Farrell was born in Rochester, New York on October 11, 1954. She spent the first 21 years of her life in that city and acquired a Bachelor's Degree in Geology from the University of Rochester in 1976. Following this, Farrell moved to the Virginia Coastal Plain (Gloucester County, Virginia) where she became a research assistant at the Virginia Institute of Marine Science. She received a Master's Degree in Marine Science from the College of William and Mary in Virginia (Virginia Institute of Marine Science) in 1980. Between 1979 and 1981, Kathleen was a field geologist for the Virginia Division of Mineral Resources at the Williamsburg, Virginia, Field Station. She mapped the Triassic-age Richmond Basin with structural geologist Bruce Goodwin (College of William and Mary) and a Coastal Plain transect (Virginia Beach westward to the Piedmont Province) with C.R. Berquist (Virginia Division of Mineral Resources). In 1981, Farrell began a PhD program at Louisiana State University specializing in sedimentology.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Kathleen A. Farrell

Major Field: Geology

Title of Dissertation: Stratigraphy and Sedimentology of Holocene Overbank Deposits of the Mississippi River, False River Region, Louisiana

Approved:

Major Professor and Chairman

F. Glen Hemby
Dean of the Graduate School

EXAMINING COMMITTEE

William H. Herke

Date of Examination:

November 23, 1987